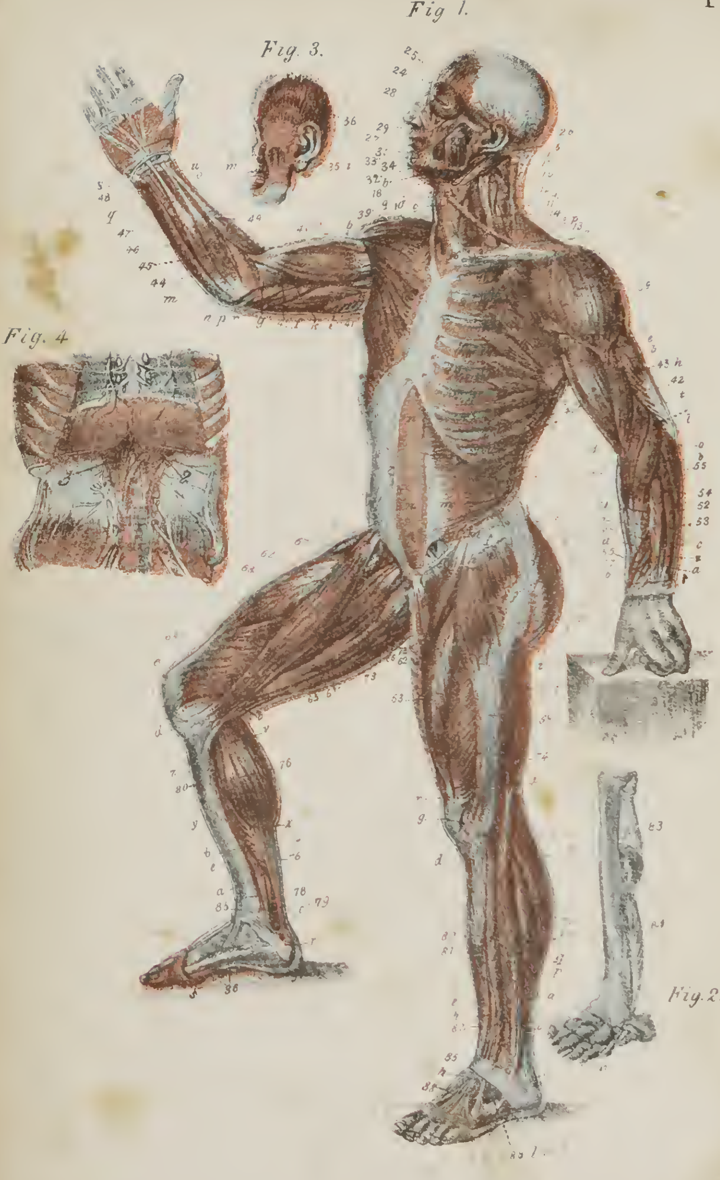
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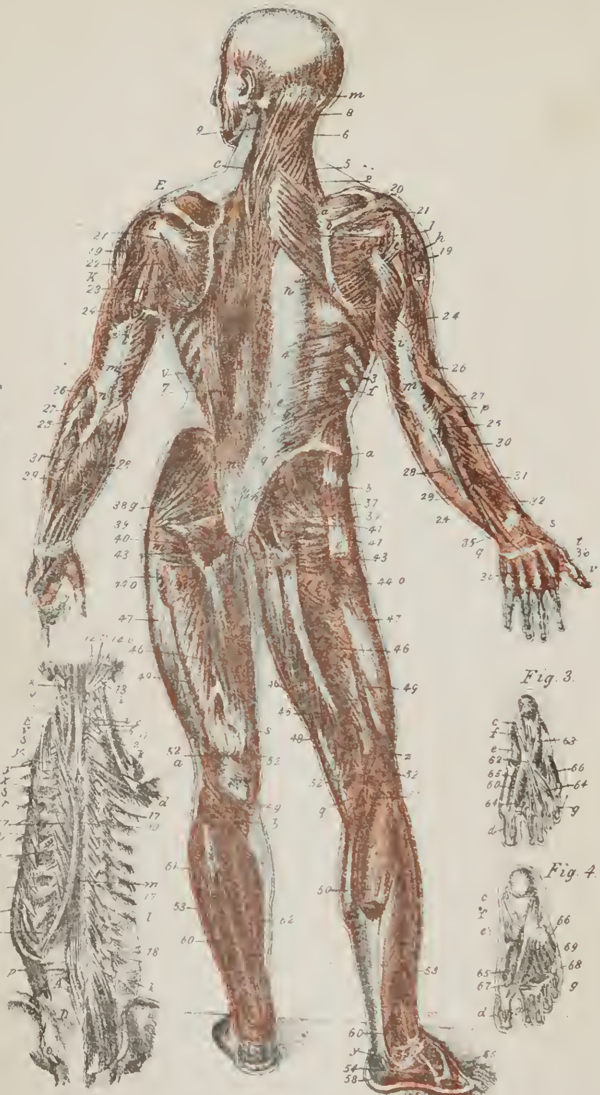

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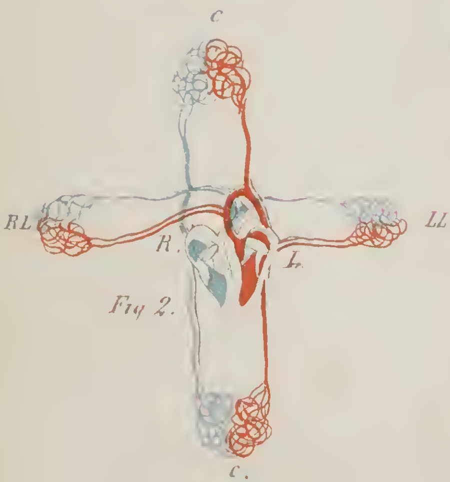

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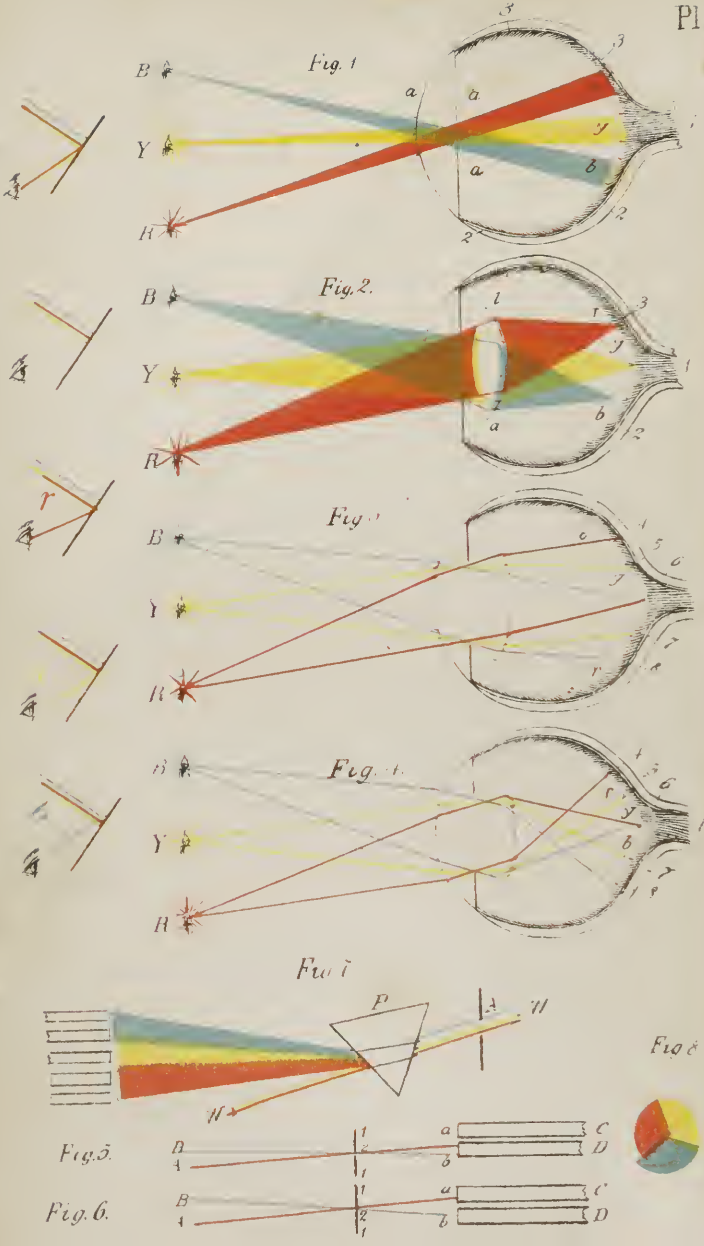

POPULAR

ANATOMY AND PHYSIOLOGY,

ADAPTED TO THE USE OF

STUDENTS AND GENERAL READERS.

BY

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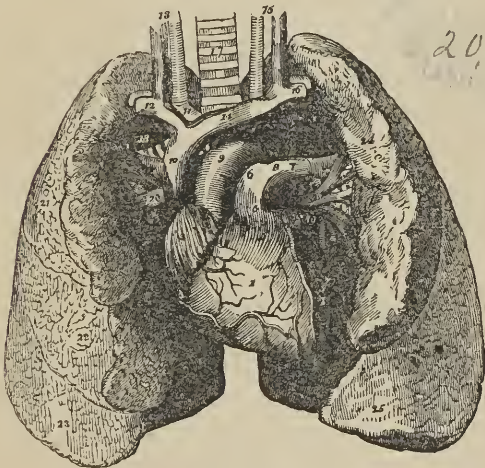

WITH ONE HUNDRED AND FIFFY WOOD-CUT AND BEAUTIFUL LITHOGRAPHIC DESCRIPTIVE ILLUSTRATIONS.

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1850.

TO

MULLER AND LIEBIG,

AUZOUX, MAGENDIE, FLOURENS, ORFILA, AND CRUVELHIER,

PEREIRA, WATSON, WILSON, CARPENTER, LISTON,

AND MARSHALL HALL,

As most distinguished ornaments of their profession and humanity;

TO

JOHN AND SIR CHARLES BELL,

COOPER, LAWRENCE, GOOD, HOME, RICHERAND, AND LAENNEC,

(Who though dead yet live,)

As those whose writings have given me the greatest pleasure and much instruction;

AND TO THE

MEDICAL PROFESSION OF THIS COUNTRY,

Whose members as a body I love and respect, from too many of whom to particularize I have been the recipient of courtesy, and from whose works and conversation a rich store of knowledge has been gathered, and used with profit in the following pages;

THIS BOOK

Is respectfully dedicated,

With the intention of rendering honor where it is so richly due, and as the only token of his admiration and indebtedness which can yet be presented by

THE AUTHOR.

CONTENTS.

BOOK II.

SECOND CLASS OF ORGANS.

DESCRIPTION OF LITHOGRAPHIC PLATES.

The minutiæ of the figures would be tedious except to the student taught by questions and answers, which last, it is best he should be taught to think out for himself. To the book of questions the reader is therefore referred for more than a general description, given here and in various parts of the text-book.

Pl. 1, Fig. 1. Represents the muscles and tendons as they appear when the skin is removed, except that the external muscles are also removed from the left side; they are shown upon the right side. The direction of the stripes shows the direction in which the muscles and parts of the muscles contract, and of course the direction in which they have a tendency to produce motion.

Fig. 2. The bones of the ankle and the internal muscles of the lower part of the leg. The tendon of 84 is seen in the most beautiful manner, turning around the outer joint of the ankle and under the foot, beneath which it passes to be attached to the bone back of the great toe.

Fig. 3.—Back portion of the jaw, the ear; and, 36, temporal muscle attached to a prominent point of the jaw, K.

Fig. 4.—Lower portion of the chest, with the front portion of the ribs removed to show the diaphragm 7, below which is seen a portion of the upper part of the abdomen, with its front wall and organs removed. 2, 3, The back lower edge of the diaphragm, the "pillars" of which are seen attached to the back-bone. The front lower edge of the diaphragm is lower than here represented, especially at the side.

Pl. 2, Fig. 1.—View of the external muscles of the back, except upon the left side, where the "middle" layer of muscles is brought to view.

Fig. 2.—Internal muscles of the back.

Fig. 3., 4.—Muscles and tendons beneath the foot.

Pl. 3, Fig. 1.—Front half of the chest and abdomen removed, presenting the organs of those parts as they would appear in front, during life. They would not appear thus however, when the body is opened, as they would flatten and change their position, hence it must be kept in mind that the organs are not flat, but project toward the observer, in the centre, rounding back at the sides, as the body does when viewed in front. 1, Right lung. 2, Left lung. 3, Diaphragm which arches up under the lungs, its front and lower edge being attached to the front and lower edge of the ribs as seen. 4, The liver, which lies up under the diaphragm in such a manner that if a knife should be thrust through where the dotted line from 3 terminates, the liver would be wounded. 5, Stomach, with arteries, represented by the little lines coming up under the lower curvature of the stomach which is represented as when distended by food. 6, Colon, where it passes across below the stomach; a white line shows one of the three longitudinal bands of muscles which contract the colon into pouches, as seen. 7, The second stomach, the commencement of which is seen in some of the woodcuts dispersed through the work. 8, Front surface of a small part of the spleen, the chief part of which, when the breath is thrown out, is above and back of the part seen. 9, The base of the gall bladder which lies forward to the edge of the liver, the upper part being found underneath the liver, between it and the colon and stomach.

Fig. 2.—Ideal view of the left lung 2, cut from side to side perpendicularly through the middle. The right lung is seen contracted, as when the chest is opened. The heart is between them. The object is to convey the idea that the air inhaled passes through the windpipe and its divisions 1, 1, into air-cells, and that the blood passes into the lungs through the artery 6, from the right heart 4, and after the blood has passed round the air-cells and been acted upon by the air, comes back to the left heart 5, through the vessels 7, of which there are two, leaving the lungs.

Fig. 3.—A greatly magnified view of the net-work of capillary bloodvessels upon the sides of the air-cells. It is not so extensive as would in fact cover the sides of a mustard seed. The blood passes in through one set of vessels and passes back through another, as the colors exhibit.

Pl. 4, Fig. 1.—The red vessels represent the arteries of the entire body branching to the various parts of the system, not precisely after the manner of the arteries of the body, but sufficiently accurate to convey a general idea. The blue vessels represent the veins.

Fig. 2.—R, Right heart. L, Left heart, from which the red vessels lead the blood into the capillaries C, C, of the body, from which it comes back to the right heart, passing thence into R, L; L, L, the capillaries of the lungs, thence back to L, left heart.

Fig. 3.—Hearts and vessels separated from each other.

Fig. 4.—Portal system of vessels. 1, Spleen. 2, Pancreas. 3, Portion of duodenum. 4, Gall bladder turned up, as better seen in woodcut. 5, Tube or duct, from the gall bladder. 6, Duct from the liver. 7, 8, Veins from the second stomach; 9, those from the stomach, which with those from the spleen and pancreas unite to form the portal vein 10, which divides and subdivides in the liver.

Pl. 5, Fig. 1.—B, Candle giving off blue light. Y, Candle giving yellow light. R, Candle giving red light. In all cases the light passes from a candle in all directions, but only so many rays as would enter the opening a, are represented. Such rays passing through the opening a, fall upon the very much magnified commencing points of the nerve 1. The light from no two candles is seen to act on any of the same nerves. 2, Outer coats of the eye. 3, Pigmentum nigrum. Neither this nor any of the succeeding figures are intended to convey any correct idea of the eye, except as it respects the action of light thrown upon the nerves.

Fig. 2.—The light is seen passing through a lens, by the action of which, the entire yellow light passing through the pupil a, is made to act on one point; the same is also true of the light from R and B.

Fig. 3.—R, Y, B, As heretofore. But in this case the lens has not acted upon the light sufficiently to cause it to act on a single nerve, but the red light acts over the nerves between 4 and 6, the yellow light acts on the nerves between 5 and 7, and the blue light on the nerves between 6 and 8 The nerves between 4 and 5, and between 7 and 8, are acted on by one kind of light only, the nerves between 5 and 6 by both red and yellow (orange), and the nerves between 6 and 7 by blue and yellow (green). This is the case with long-sighted people. Most old people have indistinct vision from this effect being produced by the insufficient action of the parts through which light passes to the nerve.

Fig. 4.—R, Y, B, As before. In this case the light is acted upon so powerfully that it is bent to points or foci before it reaches the nerve; it passes the point or focus therefore, and when it reaches the nerves, the red light acts over the space between 4 and 6, the yellow light upon the nerves between 5 and 7, the blue light on the nerves between 6 and 8, and the same cause of confusion exists as in case of Fig. 3; that it is so, is evident by bringing a thing so near to, and removing it so far from the eye, that it becomes indistinct; the sensation is similar in each case. So also when the focus of a microscope or telescope is brought toward or removed from the eye, the effect is similarly indistinct. This is the near-sighted eye.

Fig. 5.—A, B, Are two rays of different colored light passing through the hole 2, in partition 1, 1, and acting on the end of one nerve D, producing the effect of compound light.

Fig. 6.—A, B, Two rays of different colored light acting on two nerves, a simple effect being produced on each nerve.

Fig. 7.—W, a ray of white light passing through the pin-hole a, and bent upward as it is passing through the prism P. The blue light is bent the most, the yellow more than the red but not as much as the blue, while the red is bent, but less than the yellow and blue.

Fig. 8.—The three colors which compose white light upon a small card. If it be whirled rapidly on a pin thrust through the centre, the light from each part will act on the same nerves, and the card will appear white.

ADDRESS TO THE READER.

Every one desires to be happy. It seems to me a high degree of happiness can be obtained by every person if he will constantly ask himself two questions: 1st. What can he do to make others happier. 2d. What is the cause of any effect he sees. The first will improve his disposition, the second will cultivate his intellect. That increased amiability and humanity will render a person happier, needs no argument to prove; while the instant a person begins to seek the why and wherefore of things, he begins to acquire knowledge, so satisfactory and delightful to the mind, that it is stimulated to farther investigations, and soon rewarded by the most profitable results,—not the least of which will be an inquiring mind. It seemed to me, I could answer the first question in no way so well as by writing the present volume. In thus rendering others happier, my own happiness will be increased in three ways: by the pecuniary compensation received, by the esteem of community, and by the consciousness that the book is a public benefit. That the greatest effect may be produced in each of these ways, no pains have been spared to make the book valuable. That it has real

faults, there is not the slightest doubt. Many things also which displease some, will please others. Some things appear as blemishes to me, which have been allowed to remain in accordance with the opinion of some whose judgment was respected. It was intended to meet the *general* approbation of *many*, and cannot therefore, in *every* particular, satisfy *each* person, who will it is hoped consider, that our best friends have faults, on account of which many times we love them the better, as they do not seem to be more perfect than ourselves. That the treatise may render others happier, the object has been to communicate satisfactory knowledge upon the principle that,

"To please, is the first step towards instructing;"

and with the importance of the second question constantly in mind, to wit: It has been the constant endeavor to induce the reader or student to think, to inquire into causes, to lead him on step by step to the fruits of knowledge; that he may be practically convinced, that it can be usefully applied to alleviate the ills of life and increase its blessings. To know the success with which this has been accomplished, would determine in the author's mind the value of the book, to a great degree. It is therefore hoped that his opinion will never be considered decisive upon any point. The purported truths here set forth, are of the highest interest and value, if truths; they are susceptible of illustration and support, or of refutation and condemnation, in the every-day occurrences of every person's life. And so much confidence

is placed in the correctness of the views brought forward, that it is believed when they are thoroughly tested, the causes of effects, and the reasons for the beautiful operations taking place in the system, will be so clearly seen, that natural curiosity will be ripened into enthusiastic inquiry, and a spirit of investigation produced which will spurn the dictation of any writer, and acknowledge but one teacher, TRUTH.

Questions have not, therefore, been connected with the present volume, but have been placed in a separate book, because, when questions are in the hands of the scholar, he too frequently merely commits a clause which answers the question; and again, as will be seen by looking at the book of questions, many are of such a nature that the answer is not in the text, but is intended to cause the scholar to think; while as sometimes teachers, and frequently parents who would wish to instruct, might not feel inclined to take the responsibility of deciding on an answer, a correct one is given with the question, and various illustrations of the text, which might not otherwise suggest themselves to teacher, parent or scholar; many teachers also prefer to ask their own questions, suggested by the text. As the treatise is designed to be a book for general reading as well as a text-book for students, it was thought an advantage to have the questions optional; though, being separate, many facts can be communicated and suggested by them which could not consistently be introduced in the text, and will render it a pleasure for the general reader to notice the questions. With them the parent can with perfect ease teach his child the important truths of this science, at an early age, there

being but one suggestion to make ;—that the child, older or younger, receive very short lessons. A lesson containing one practical truth will be sufficient ; this being so illustrated and applied, which the questions will do, that it will become part of the student's nature to be actuated by the grand principles which the Creator has appointed to govern the physical welfare of man. These truths, these principles, he should learn so thoroughly, by having them frequently brought before the mind and fully illustrated, that he shall be actuated by them unthinkingly, and entirely forgetful of their source, consider them merely as indubitable, and teach them to others as truths, the observance of which bestows the greatest physical blessings. That thus the knowledge which it is believed this book can impart, may be the means of adding to the happiness of many who shall never hear of the name or existence of the author, is my sincere wish.

New-York, Nov. 1, 1849.

THE

ANATOMY AND PHYSIOLOGY

OF THE

HUMAN SYSTEM.

INTRODUCTION.

1. The object of the following pages is, to prove that Beauty, Health, Strength, and Length of Days, mental and physical, depend upon observing certain Laws—to unfold and illustrate these Laws, and enforce the importance of obeying them.

2. This will be attained by imparting the knowledge establishing these laws, and by examining the four sources from which it is derived.

3. *First.* The structure of the Human System—HUMAN ANATOMY.

4. *Second.* The uses of the Human Organs—HUMAN PHYSIOLOGY.

5. *Third.* The concurring testimony of all men—UNANIMOUS EXPERIENCE.

6. *Fourth.* The particular experience of each person—PERSONAL EXPERIENCE.

7. Three difficulties attend an investigation of these sources of knowledge:—

8. The first arises from want of proper means to see and

dissect minute parts of the body, and examine the delicate operations that take place therein.

9. The second is owing to the infrequency of opportunities for observing the interesting phenomena of internal life.

10. The third and greatest difficulty is found in reconciling conflicting testimony, and sifting from it all prejudice and bias.

11. However, a doubt will but rarely exist if the testimony from each source be obtained upon any point. For the testimony from three sources agreeing, it would correct the contradictory testimony from the other.

12. The knowledge from the fourth source being personal, can only be obtained by learning the experience of each person, when the laws peculiar to him may be established.

13. The laws based upon the knowledge drawn from the first three sources are to be learned and observed by all, since they are universal and invariable. They may with propriety, therefore, be laid down in books, and profitably acquired therefrom.

14. To do this most successfully and concisely, man may, firstly, be considered under the heads of Mind and Body.

15. The Mind is that which thinks, feels, and causes voluntary action; is properly the man.

16. The Body is a beautiful piece of mechanism, composed of many parts, adapted to the use of the mind, with which the mind thinks, feels, and acts.

17. Mind and body are so intimately connected with each other, and so powerfully influence each other, they cannot be considered distinctly. The state of one always affects that of the other. The tears flow profusely when the mind is overcome with grief. Anger reddens the cheek, which is paled by fear. While, *vice versa*, too much food unfits a person for study; but wholesome food, and a healthy digestion of

it, give vigor to the mind and life to the spirits. As Tupper so eloquently writes,—

> "The best cosmetic is a holy conscience;"

or as Thomson,—

> "E'en from the body's purity, the mind
> Receives a secret sympathetic aid."

18. Indeed, whatever elevates the intellect, regulates the passions, sweetens the disposition, or cultivates the affections, tends to develope beauty, preserve health, increase strength, and prolong life.

19. On the other hand, ignorance, ungoverned temper, moroseness, and sensuality, will despoil the fairest intentions of nature, develope disease, enervate the system, and produce untimely death.

20. This is not the place to treat on morals; yet it may be observed, that our Quaker friends are not a little indebted for their celebrated complexions, good health, and long lives, to the healthful moral influences with which they surround themselves.

21. So much do the manifestations of the mind depend upon the state of the body, some have too hastily concluded, mind was only the necessary result of action of certain parts of the body.

22. An attempt will be made in various parts of this work, to show clearly, that the distinction between mind and body is correct.

23. As they depend so intimately upon each other, if one be considered, the other is necessarily involved; and it is enough, therefore, that especial attention be given to one; and in the present work, it is our duty to take the body for the particular topic of discourse.

24. Of the body, two classes of organs will be considered. For though it is a whole, and each part affected by every other part, yet—

25. One class of organs is used with which to think, feel, and act;

26. Another, to keep the first class, and also itself, in good condition.

27. The first class may be subdivided into three classes of organs, which include—

28. 1st. The brain, with which to think;

29. 2d. The organs of sense, nerves, and brain, with which to feel;

30. 3d. The bones, cartilages, ligaments, muscles, nerves, brain, and some minor organs, with which to act.

31. The utility of the second class of organs will be better perceived after the first class has been described.

32. The propriety of dividing my subject into two books will now be seen, and the subdivisions of the first book will be anticipated.

BOOK I.

THE FIRST CLASS OF ORGANS.

CHAPTER I.

THE ORGANS OF VOLUNTARY MOTION.

SECTION 1.—*The Bones, Cartilages, and Ligaments.*

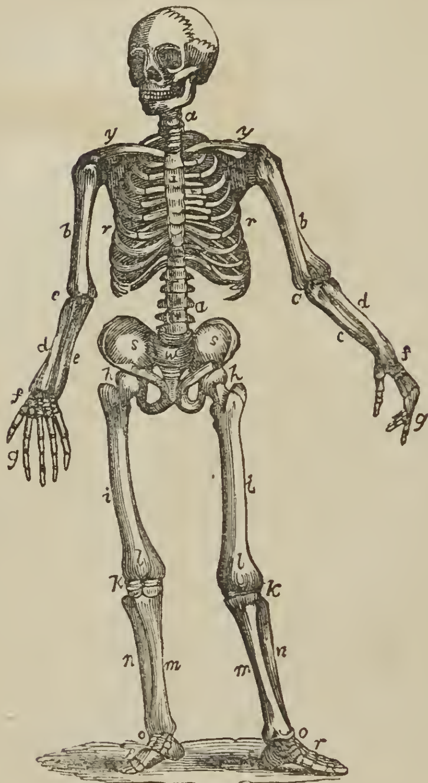
33. These parts form the framework of the human system.

34. The use of this framework is to give form to the body,* to support the soft parts in their proper positions, to protect some of them, to allow motions of one part upon another, and of the whole, from one place to another.

35. To fulfil these requirements the frame must be very strong, of sufficient size to admit the attachment of the numerous soft parts, yet very light; it must be composed of many pieces, very strongly united, yet in such a way as to allow the desirable motions, with the least friction.

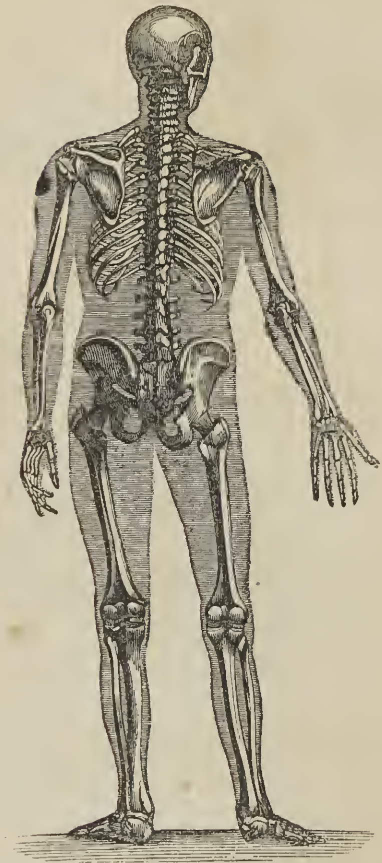
* Since the general form depends upon the skeleton, every lady desiring to possess, or desiring her child to possess a fine form, will feel exceedingly interested to know all that can be learned in respect to the bones, and anxious to do every thing which will perfect them.

Fig. 1.—Skeleton, Front View.



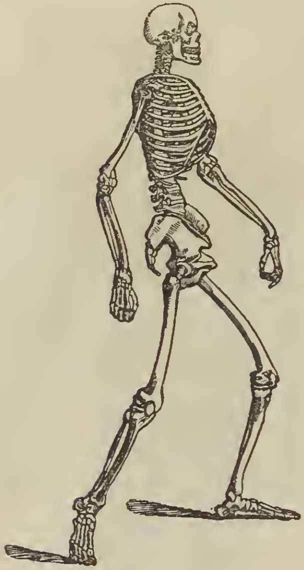
36. Composed of bone, cartilage, ligaments, with some minor adjuncts, the frame is perfect in all these respects; I know not which to admire the most—the perfection of the bones, the elasticity of the cartilage, or the strength and beautiful arrangement of the ligaments. Our hearts are moved with adoration when we read the handiwork of the Creator

Fig. 2.—Skeleton, Back View.



in the superlative form and texture of the skull; but not less are they moved with gratitude as we view the cushion-like cartilages supplied to the back, or the powerful bands which unite all parts into one.

Fig. 3.—Skeleton, Side View.

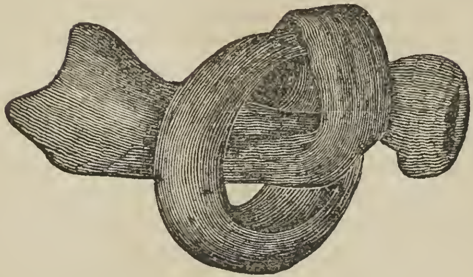


37. The bones are adapted to their purpose by their composition, form, and being hollow.

38. They are composed of two substances; one soft, the other hard. The two and their nature can be easily perceived, if two similar bones be placed, one in fire, and the other in some diluted mineral acid. In a short time, if taken out, though both have the same form as before, one will bend, indeed may be tied in a knot (Fig. 4), the other will crumble like chalk, the acid having removed the hard or earthy portion, and the fire destroyed the softer or cartilaginous portion. The form of each being the same as before the experiment, it will be seen that the hard and soft parts are intimately blended throughout the bone.*

* Sometimes, by disease or some cause, the hard part is removed from the bone during life, and the bone thus affected will bend in any direction,

Fig. 4.



39. The proportions of the two parts to each other vary much under different circumstances.

40. In earliest life the soft parts only would be found; at a certain time a few particles of the hard part are deposited in one or several points of the soft part, called "points of ossification;" additions are then made, till throughout the soft part the hard part would be found, but in very small proportion; this, however, is gradually increased by fresh additions throughout, till at last the bone has sufficient strength to bear the weight of the child. The hard or earthy part continues to increase till old age, in mature years giving the bones the greatest degree of strength, and in advanced life making them extremely brittle.

41. In some bones the deposit is made much earlier and more rapidly than in others of the same body.

42. In some children also than in others.

43. These statements will account for the bones of children bending easily and breaking with difficulty, while those of old people break easily and do not yield to pressure. The

and people will say the bone is gone. I have seen one such case, the upper arm bone of a young man, 18 years old: the cause I could not learn; the ultimate effect I have not yet heard. In other respects he seemed to enjoy usual health.

predominance of the soft part is also one reason why, if the bones of children be broken, they unite readily, while in old people the predominance of the earthy part retards the process of restoration and sometimes prevents it.

44. It would be inferred, that a child does not walk earlier because it is not fitted to do so; therefore no pains should be taken to teach a child to walk by using standing-stools or the like. Even leading a child, or standing a child upon its feet must be wrong; placing a child in one position, long or often, should be avoided; so also, placing or carrying a child in such a position, that much weight shall be borne upon one part of the body, cannot be right.

45. It must be evident that the heavier a child, the greater the effect and necessity for care.

46. Is it not probable, also, that if a child be backward it is for some good reason, and will it not prove injurious to attempt to teach the child to walk?*

47. That this hard part may be deposited, it must be furnished to the child in its food. Now, it must be evident that milk contains this substance, as it has been designed by the Creator for the use of young animals, and because we see the bones of animals become strong and good, when nothing but milk is used as food. As the works of the Creator are so perfect, can it be best to go contrary to his evident intentions, and feed a child with any thing but milk? Indeed it is not impossible that chicken-breasted and other deformities, the result of too soft bones, may be in part or wholly

* I do not believe that a child can be advanced one day by attempts at teaching. It seems to me that a child walks as other animals, actuated by an instinct, and will of its own accord, and untaught, walk as soon as it should, as soon as it can. Some may say that exercising a child will give it strength earlier; but, with the delicate muscles of the child, over-exercise, rather than want of it, is to be feared; and the bow-legs, chicken-breasts, and other deformities so common, show that the other animals are more favorably situated in this respect than the human species.

produced by feeding the child with arrow-root and the like, especially as it will be hereafter shown that such things tend to increase the weight of the child by fat, an end not desirable, and cannot strengthen the bones, which is of primary importance.

48. The forms of the bones are so various, and the bones are so exceedingly irregular, it would at first seem there could be no general plan by which they were all made. Quite the reverse opinion will be formed on examination.

49. The numerous indentations upon the surface of the bones, are evidently for the purpose of obtaining a greater extent of surface for the attachment of soft parts; the prominences serve the same purpose, and also act as levers (Fig. 5). Many times a ridge is seen upon a bone (Fig. 6), which adds greatly to its strength and scarcely any thing to its weight.

Fig. 5.

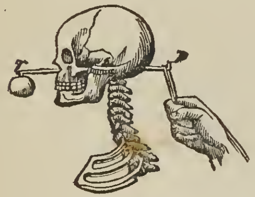


Fig. 6.

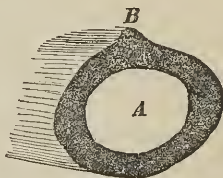


Fig. 5.—*r*, A resistance. *p*, A power acting on the lever (*r p*), of which the skul. is a part. From *r* to the skull, and from *p* to the skull, represent prominences upon the bones; the longer these are, the greater the effect of any force acting upon them.

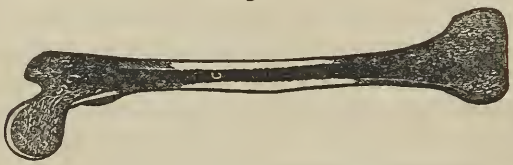
Fig. 6.—Section of a bone, with a ridge (B) to strengthen it. A, The hollow of the bone.

50. If the bones be examined in almost every exposed position, the form will be that of the arch, the strength of which is seen in the stability of the bridge supported by arches. See the beautiful form of the Skull, which has been demonstrated to be the most perfect possible.

51. The bones being hollow (Fig. 7), is an exceedingly ingenious arrangement, as thereby they may be large and

strong, and yet light. At first it does not seem consistent that the bones are as strong, being hollow, as they would be if solid. But if a green twig be broken, the outer layers will be seen to give way first, when the inner layers immediately break. Notice also how heavy a head of grain a single straw will support, even when the wind is blowing furiously, and it will be evident the hollowness of the bone is as it should be.

Fig. 7.



52. The outer surface of the bone is more solid or dense than the part within, which grows more and more spongy-like in appearance, though it is firm to the touch, till in the centre of the long bones a perfect hollow would be found.

53. The bones are also able to resist the effect of blows and weight, by the assistance of the soft parts, which being attached to the bones, act sometimes as stays, and being elastic, at first yield, but gradually resist, and at last very firmly.

54. All the bones are covered by a very thin but strong skin or membrane; when dry and peeled from the bone, it appears like tissue parchment. It is called the Periosteum (about bone). Upon particular bones, however, it is called by specific names, as that upon the skull is called the Pericranium (about cranium).

55. Wherever the bones are hollow, a similar membrane exists lining the cavity.

56. Upon the healthy condition of these membranes depends the healthy state of the bony layers under their imme-

diate influence. Hence disease of this membrane speedily produces the most tedious diseases of the bone.

57. Two diseases, called in common language, "fever-sore," and "felon," are similar affections; one, of the periosteum of the long bones; the other, of that of the shorter bones.

58. "Felon" is usually soon detected, but "fever-sore," which is much more serious in its consequences and extent, is usually mistaken, till it is too late to call in the assistance of the skilful surgeon with the most effect.

59. There is, however, a striking difference between the pain produced by this complaint and rheumatism. It usually occurs in young persons who are not likely to be troubled with rheumatism, which is apt to manifest itself about the joints, and either affects several at once, or wanders from one to another. In fever-sore the pain is not felt at the joints, is local, continuous, and increasing.

60. The instant the existence of the disease is suspected, the advice of experience is required, as the disease can be readily conquered, only during a few days of its commencement. If it be decided that an operation is required, such as cutting down to the bone to cause bleeding from the inflamed bloodvessels of the diseased membrane, or perforating the bone, that the internal membrane may be reached, it will not answer to hesitate, for while indecision is waiting, the disease will gain a firm foothold; or if it be determined that the continuous application of cold will disperse the blood from the part and change its action, it is plain that directions must be very promptly and thoroughly followed, as the danger is immediate and imminent.

61. If the bones were brought directly in contact with each other, their composition is such, that the most unpleasant jars or concussions would be produced, even when walking in the gentlest manner, and every motion would produce harmful friction.

62. To prevent such results, the bones at the points of contact are covered with cartilage, or what is commonly called gristle; it also serves to lengthen out some of the bones (as the ribs, Figs. 1, 2, and 3); to increase the security of the joints (Fig. 8); and as cushions (Fig. 9), by the yielding of which as a whole, or upon one side or the other, the supported parts are carried with the greatest safety, or bent with the greatest ease.

Fig. 8.

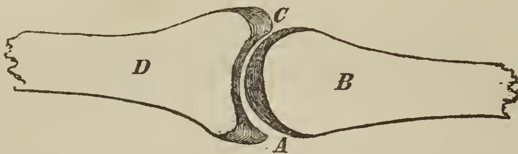


Fig. 8.—D, Body of a bone, at the end of which a socket is found. C, Cartilage, thick at the sides, and thin in the centre. B, Body of a bone, at the end of which a round head is found. A, Cartilage, thin at the sides, and thick in the centre.

63. Cartilage is admirably adapted to its purpose, by its capability of receiving a smooth finish, of which any one may satisfy himself by examining almost any movable joint of an animal, but especially by its elasticity; that is, when acted upon by force it yields, but returns to its former position and conditions when the force is removed.

64. Its elasticity depends upon its composition, which varies with its situation and use, the person examined, and the period of life when the examination is made.

65. The general rule is, that the cartilages grow thinner, firmer, and less elastic, with increasing age. This will account for the shortened stature of old people, as well as the stooping form;* for by Figs. 1, 2, and 3, it will be seen

* Would it be a good thing for the old man to be straight, when the elastic springs, cushions, or cartilages of his back have become unfit for the fulfilment of their duty? Evidently not. Every jar received by the lower parts of the body would be transmitted in a direct line to the head and nervous system; and such continually repeated concussions, though slight as possible, would shortly destroy life.

Fig. 9.

Fig. 9.—Back bone, spinal column, vertebral column. *b*, *c*, *d*, Bodies of vertebræ; the projections on the opposite side are called spinous processes; above *b* they incline down but little; between *b* and *c* they incline very much; between *c* and *d*, but little, if any. Spaces between vertebræ are filled, in life, with the cushion-like cartilages. Above *b*, are the cervical (neck) vertebræ; *b* to *c*, dorsal (back) or chest vertebræ; *c* to *d*, lumbar (loins) vertebræ; *d*, *e*, sacrum; *e*, *f*, coxcyges.

that the cushions of the back, if diminished in thickness, will allow the head and entire trunk to fall forward.

66. But with the head leaning forward, works on Natural Philosophy (see "Composition of Forces") will show, and experience proves, the danger is avoided. I would here observe how, upon examination, all things are found to be most admirably adapted to our good, when at first glance there would seem to be something to correct. There is a rich treat and great practical source of knowledge to the man who will ask the why and wherefore of what he sees.

67. In some instances the cartilages become bony, or technically, "ossified," in advanced life.

68. To retain the bones and cartilages in their places at the movable joints, something of great strength, yet possessing a certain degree of flexibility, is required, to stretch across from one part to another and be firmly united to each. Such is the nature of the ligaments.

69. They are the pearl-colored, lustrous, strong parts, found about the joints of any animal. They are in the form of straps (Fig. 10); in the form of bands completely surrounding (Fig. 11); or in the form of cords. They are sometimes found within the joint, but usually without, stretching between, growing to, and binding together the different parts, allowing motion in required directions and preventing it in others.*

* It does not seem judicious to speak of any course which should be pursued, till its propriety has been proved. But sprains, strains, or wrenches of the ligamentous parts are so common, a word in respect to them will be expected here. They will be again spoken of in an advanced part of the work, when the why and wherefore will be clearly given; as it is easily shown, that lotions, plasters, and all this class of things so commonly used, are of little worth, and cause fruitless expenditures of trouble, time, and money; while time, patience, the application of heat or cold, with rubbing, are chiefly to be depended upon. If there be heat or redness of a sprained part, and almost always if there be pain, the part must be kept perfectly quiet, rubbing avoided, and cold applied till relief is felt and the heat subsides. Sometimes persons have,

Fig. 10.

Fig. 10.—Represents the strip-like ligaments which pass across from one bone to another in the hand, and also the inter-osseous (between-bone) ligament which connects the bones of the lower arm.

70. Atmospheric pressure is also thought to exert a powerful influence in retaining the bones. I have seen a statement that forty pounds weight was required to draw the thigh

under such circumstances, pumped cold water upon a sprained ankle, and learned from experience the benefit. If the part be cold and inactive, brisk rubbing and the application of heat will be advisable ; and application of substances irritating to the skin may be made, if desirable. The part may be wrapped in flannel or a cloth dipped in warm water, and covered with oiled silk ; but the chief dependence must be placed, in all cases, on time, patience, and rest. If the part be used from time to time, it will be a long while, perhaps years, in recovering. By long disuse a part is apt to be stiff, when in fact it is well ; it should then be rubbed often and thoroughly, it being certain that no inflammation exists, which will be manifested by pain and soreness ; and forced motion be produced, slight at first, but increased from day to day till perfect action of the part is obtained. The restoration of sprained parts is so slow, there is great difficulty in persuading a person to wait and avoid exercise.

Fig. 11.

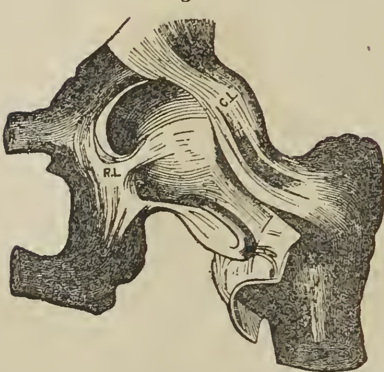


Fig. 11.—The hip joint opened. C L, Capsular ligament, which, like a band, passes round the joint, attached on one side to the hip, and on the other to the thigh bone. R L, Round ligament passing from nearly the centre of the round head of the thigh cone to nearly the centre of the deep socket.

bone from its socket, after all its connections had been severed, indeed, after it had been entirely removed and was replaced. We see this principle so simply and successfully used by the dentist and others, that there will be no objection to allowing its application in case of the joints.

71. The fleshy parts clothing the bones serve also to retain the bones when in place, but exert an equally powerful influence to prevent their return when dislocated.

72. Notwithstanding the admirable structure of the cartilage, the almost constant, slight or extensive motion at the joints would produce serious friction.

73. To prevent this as far as possible, the movable joints are lined with a membrane or skin called "synovial membrane." It is attached by one side to the cartilage (Figs. 12 and 13), the other being "free," that is, not attached to any thing.

74. In this membrane an exceedingly glairy fluid, well adapted to its purposes, called "synovial fluid," is found. It

Fig. 12.

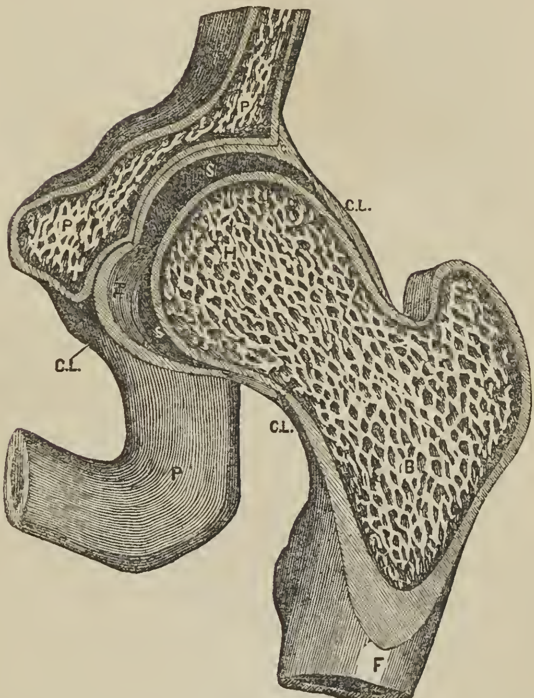


Fig. 12.—C L, Capsular ligament. R L, Round ligament. F, Thigh or femor bone. B H, The same sawn open, exhibiting the marrow-filled cells composing the internal parts of many bones, as at P P also. P P P, Hip bone. S S, Space filled with synovial fluid, but here represented as much greater than in reality, the surfaces of the synovial membrane in fact being closely in contact.

exudes from the free surface as the minute drops of perspiration, when scarcely perceptible, on the face.

75. But the fluid would accumulate, or remaining, would be liable to the same fault as even the most delicate oils which human art has obtained: viz., would thicken, and render a "cleaning" of the joints necessary, were it not for another

Fig. 13.

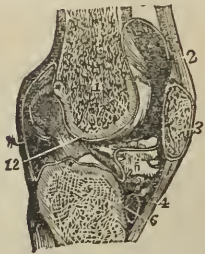


Fig. 13.—Knee joint. 1, Lower end of thigh bone. 5, Upper end of "shin" bone. 3, Knee-pan. 2, Tendon of muscles acting on knee-pan, or *patella* or *rotulla*. 4, Ligament connecting patella to "shin-bone," or *tibia*. Stars show the synovial membrane. 6, A *bursa*, or pouch or purse.

duty the synovial membrane performs. It continually takes up and removes the fluid which a short time before was deposited.*

76. The bones of the skeleton are 240 in number, not counting several small bones, which are considered as accidental and not necessary to the framewcrk.

77. Most of these are united, so as to form movable joints, some so as to form immovable joints.

78. The eight bones of the skull (Fig. 14) are of this last class.

* Though only a drop of fluid, perhaps not as much, would be found in a healthy joint at any one time, one author has computed that not less than five quarts of synovial fluid is required in 24 hours by the joints of a laboring man.

In this, as in many other cases, it is evident that one part performs more than one duty, though the contrary is frequently asserted; it is also evident that the same symptoms may be exhibited by different causes; for an accumulation of fluid in the joints may take place, either because it is formed too rapidly, or not removed as it should be. How absurd then the idea that one medicine shall cure all diseases having the same symptoms—and how much more absurd that any medicine or course of treatment shall cure all diseases. It must be evident, if disease exist, the *cause* must be looked for; if this be done in season, and the cause prevented from further action, rarely will any thing else be required. But it will be perfect nonsense to attempt to remove disease while its causes are still existing to reproduce it.

Fig. 14.

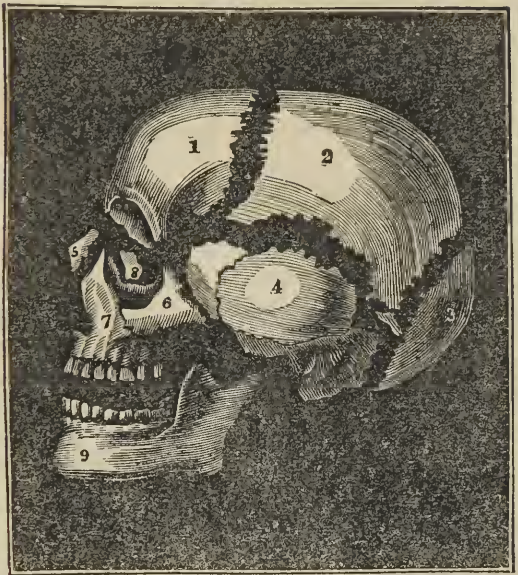


Fig. 14.—The bones of the skull separated. 1, Frontal, only half seen. 2, Parietal (wall). 3, Occipital (back), only half is seen. 4, Temporal. 5, Nasal (nose). 6, Malar (cheek). 7, Superior (upper) maxillary (jaw). 8, Unguis (nail form, being about the size and thickness of the fingernail). 9, Inferior (lower) maxillary (jaw). Between 4 and 6, a part of the spenoid or wedge-shaped bone is seen. Another bone assisting to form the skull, but not here seen, is called the ethmoid (sieve-like, from being full of holes) and situated between the sockets of the eyes, and forms the roof of the nose. 2, 4, 5, 6, 7, 8, are double. The small bone, and others like it, seen in a line between 3 and 4, are called ossa triquetra.

79. Each of the eight is composed of three layers differing from each other in their structure.

80. The outer layer is quite tough, and called the fibrous or external table of the skull; its edges are notched very irregularly to appearance, but so that each bone of the skull perfectly corresponds with its neighbor, into which it is locked, or dovetailed, as the expression is; hence it must be formed upon some uniform and general principle.

81. The joints formed between the external tables are called sutures or seams; these are also called by specific names, as the sagittal suture, coronal suture, squamous suture, &c.

82. Small bones, called ossa triquetra, are also seen in Fig. 14, which may or may not be present: their utility is not appreciated

83. The middle layer or table is cancellated or spongy, and lessens the jarring effect of blows upon the skull.

84. The internal table is called vitreous or glassy, as it is very brittle. If its edges were like those of the external table, a slight blow upon the head would break off the points; hence its edges are square, and an even-looking joint is the result.

85. In advanced age the sutures are sometimes closed up by the bones uniting together firmly. In early life, on the other hand, the firm bone has not covered the whole brain, but "soft spots" exist: the one on the top of the head, called a fontanelle, being an example, where, by pressure, the head may be lėssened in size, and other benefits obtained.

86. The bones of the face, fourteen in number, are immovably united, except the lower jaw; its joint allows of motion downward, upward, forward, backward, and from side to side.

87. The socket in which the lower jaw moves is so shallow, that sometimes a person, by opening the mouth wide while gaping or the like, throws the jaw from its place, and cannot have his "gape out," till something be done.

88. To replace the jaw, let the thumbs of a person be placed against the lower back teeth, and the fingers under the chin; press downward and backward with the thumbs, and try at the same time to raise the jaw with the fingers. From the frequent and powerful motions of the jaw, its joint is subjected to unusual friction. To diminish this the joint is sup-

plied with an extra cartilage, and with two synovial membranes. By means of these the same end is obtained as the maehinist gains by frietion wheels (Fig. 15).*

Fig. 15.

Fig. 15.—Section of the joint of the lower jaw. 3, Cartilage dividing the joint into two parts. 4, The upper, 5, the lower cavity, both lined with synovial membrane. 1, The socket in the bone which receives the upper surface of the cartilage. 7, A portion of the lower jaw, which moves upon the under surface of the cartilage. 6, The cartilage taken out of the joint

89. Composing the baek-bone are found 24 vertebræ, placed one above the other, the lower one resting on the sacrum, which is terminated by the coceyx (Fig. 9).

90. Between the upper or first bone and the head, what is ealled a hinge-joint is found, whieh allows the nodding motion of the head, and with great rapidity, if desirable.

91. The first and seeond bones are united in a very eurious manner. From the second bone a prominenee, called a tooth or pivot, rises up through the first, and is attaehed to the skull by a ligament passing between them. Another ligament passes from side to side of the first, behind the tooth, whieh has a kind of neck at the point, where this ligament aets against it. Thus every thing is held firmly in its place, and yet the most desirable rotary motion of the head with great quickness is allowed.

* The bones of the ears, the teeth, and the U-like or hyoid bone will be described hereafter.

92. Motion of the other bones of the back is obtained by cartilages situated between the "bodies" or front parts of the "vertebræ"(Fig. 9). These are much thicker between the lower than between the upper bones of the back; they are also much more firm at the outer surface than within, where the substance more resembles jelly. In some animals, indeed, the centre is found occupied by a bag or bladder of quite fluid substance, by means of which still greater suppleness is obtained.

93. As the bones are drawn towards each other, this substance pressed upon, yields, becoming thinner at that point and thicker at the opposite side. Thus, by acting upon the bones in the proper way, any desired motion is obtained. But joints of this kind do not allow of the greatest rapidity of motion, even to the frequently exercised back; hence a different arrangement is found in case of the two upper bones, by means of which the desirable rapid motions of the head are gained to perfection.

94. To the "back-bone" the ribs are attached, forming hinge joints, by means of which they can be moved upward and downward. By their form and composition they are remarkably elastic for bone; they pass around to form the sides of the chest, and are lengthened out by means of cartilage, which is very elastic in early years, but firmer in advanced life, and sometimes, in old age, changed into perfect bone. From the upper seven, which are called the true ribs, the cartilage becomes attached to the "*breast bone.*" From the three or four next, the cartilage passes up and becomes part of that from the rib above; while the lower one or two ribs are merely tipped with cartilage, and called floating ribs.

95. Such a framework as the chest was required to give support to the arms, and was also needed to protect the lungs and heart; hence the ribs are used to fulfil both purposes; at

the same time it was necessary also that the ribs should not be immovably attached to the back-bone, or how could a person bend the back? Motion of the ribs was also necessary in the process of breathing; hence we see that not only one end, but several, are gained by the same beautiful and simple means.

96. The shoulder-blades are suspended, as it were, by the fleshy parts, to the ribs and back-bones, and they lie upon the ribs, though not directly, as the flesh beneath prevents them from coming in contact with the ribs. It is important that the arms of man hang by his side; in the cow, or horse, or dog, &c., it is important that they be, as it were, in front. In man, therefore, the shoulder-blades are prevented from falling upon the chest at the sides, by the collar-bones, which are wanting (except mere rudiments) in the animals above-mentioned.

97. At one extremity the collar-bones are connected to the breast-bone; at the other to the shoulder blades (*y*, Fig. 1), forming joints which allow of limited but sufficient motion.

98. Placed in this manner the shoulder-blades can move upward, downward, backward, forward, or in a rotary manner, with the greatest freedom, and without particularly affecting the ribs, while their position in relation to the ribs is such, that all deformities of the chest, at the back part, whether of the back-bone or ribs, will be exhibited by the shoulder-blades.

99. At the shoulder, the upper arm bone (*b*, Fig. 1) is connected with the scapula or shoulder-blade in such a manner as to form what is called a ball and socket joint.

100. By this means and the mobility of the shoulder-blades, the greatest latitude of motion is allowed to the arm and hand. That this may be increased to the utmost possible degree, the socket has been made exceedingly shallow. Were it not for the cartilage that deepens it, it could hardly be

termed a socket. On this account the bones at the shoulder are more easily dislocated than any others.

101. A hinge joint is found at the elbow, by which the hand can be raised up and thrown down; but lateral motion is prevented both by the form of the bones and the arrangement of the ligaments. At the lower and back part of the upper arm bone or humerus, a cavity is found, into which the hook-like prominence felt at the elbow shuts, when the hand is thrown down. It is so arranged that the bones of the lower arm will never be in precisely the same plane with the upper bone.

102. Another but smaller cavity, opposite to the first mentioned, will be found at the front and lower part of the humerus. A correspondingly small point of one of the bones in the lower arm shuts into it, preventing the bones of the lower arm from being brought parallel with the humerus, whereby great safety of the joint is insured.

103. No arrangement in the body is more ingenious than the combination of the two bones in the lower arm, by means of which we turn a gimlet, a key, and perform all such useful motions. Here are two bones, the "ulna" (*e*, Fig. 1) and "radius" (*d*, Fig. 1). The upper end of one, with the humerus, forms the elbow joint; the lower end of the other, with the wrist bones, forms the wrist joint, and *vice versa*—the upper end of the radius forms no part of the elbow, neither does the lower part of the ulna assist in forming the wrist joint.

104. The rounded upper end of the radius, which is the bone back of the thumb, turns in a slight cavity in the upper part of the ulna, its fellow, and is fastened there in such a manner as to forbid, release, but yet allow of a turning motion. Between the bones (Fig. 10), for their entire length, a ligament is found, strong but very complying, and at the lower extremity of the radius, the hand is attached; when, there-

fore, the radius is rolled over the ulna, which remains quiet, the hand is made prone or supine (palm downward or upward).

105. The wrist joint is a compound hinge joint, permitting motion of the hand up and down, as well as from side to side.

106. The wrist is composed of eight bones, small, but united in a manner so exceedingly strong, that the hand must be crushed before they can be displaced.

107. To the wrist are connected the several bones which form the frame of the hand; to these again the bones of the fingers, the arrangement of which is so simple and evident, that a child may study them without a tutor.

108. To the lower part of the sacrum (Fig. 9) the coccyx is attached. This is composed of several bones, early in life; at a later period they become consolidated with each other and also with the sacrum.

109. To the sides of the sacrum (*w*, Fig. 1) are attached the hip bones (*s s*, Fig. 1), bound in their places very strongly by ligaments. They are very irregular in form, and unite with each other in the front central line of the body by a joint called "symphysis pubis." It is of the kind which does not allow of motion or separation of the bones, except with the severest effort.

110. In the outer sides of these bones, looking somewhat downward, deep sockets are excavated, in which are placed the heads of the thigh bones. These heads will be observed not on the end of the shaft, but connected with it (Fig. 16) by the neck.

111. "Hip disease" may profitably be noticed, as its worst results may often be attributed to ignorance of its early symptoms or injudicious neglect. One of its first symptoms is, pain at the knee, with no apparent cause. Secondly, the child will stand mostly on the sound leg. Thirdly, if pressure be made upon the hip joint and the leg rolled around, pain will be felt in the hip, if disease exist. The advice of a

Fig. 16.

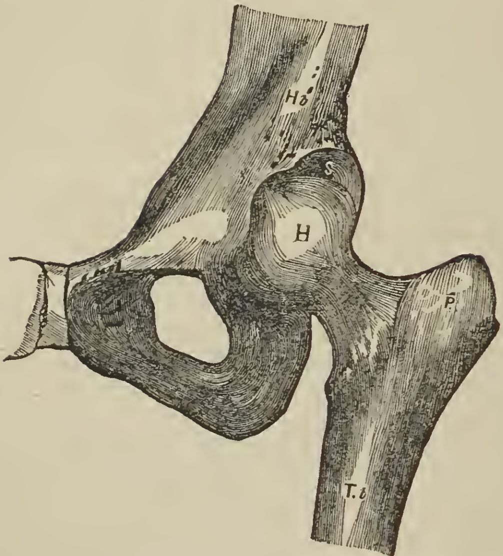


Fig. 16.—H, Head, or ball. N, Neck. P, Prominence. T *b*, Body of thigh bone. S, Socket. H *b*, Hip bone.

skilful surgeon, must then be very strictly followed, and it is advisable to read some good treatise (Liston or Cooper) on surgery, that speaks of the disease in particular, as almost every thing depends upon good nursing for a long time, of which the patient must be persuaded, or he will perhaps be seduced by the promises of unprincipled quacks, whose character he learns too late.

112. The twisted form of the thigh bone or "femur" (*i*, Fig. 1), is remarkable; being uniformly so, it doubtless serves some important purpose. At its lower extremity (*l*, Fig. 1) it is much enlarged, and forms, with the enlarged upper extremity of the "tibia" or shin bone (*m*, Fig. 1), the knee joint, by which the foot and lower leg is flexed

backward to the greatest degree, and brought again into a perpendicular below the femur, its further motion forward being prevented by ligaments. At first view this would seem to be one of the weakest joints, but the motions required of it are so simple that it can be, and is, made exceedingly strong by ligaments. Subject to great and almost constant pressure, it has been furnished with extra cartilages (Fig. 13), which placed between the bones and covered on both sides with synovial membrane, render it quite perfect.

113. In front of and sliding over this joint, is found the "knee-pan," to be hereafter spoken of.

114. In the lower part of the leg are two bones, stronger and presenting more surface than if but one, especially as there is a ligament stretching between them for their entire length. They also serve as supports to each, if either be broken.

115. At their lower extremities is found the ankle joint, a part exceedingly subject to be sprained, as it was necessary to produce by it a double motion, up and down, and from side to side. It could not, therefore, be endowed with the strength of the knee. The force which is exerted when the weight and entire lever power of the body is brought to bear on the ankle, placed in an improper position, is but little appreciated. With a sprained ankle, therefore, the greatest care must be taken; for a slight misstep will undo the curative process of weeks.

116. The ankle bones, seven in number, resemble the wrist bones in the strength of the bands which confine them together. With the bones stretching forward to the toes, they form an arch (Fig. 17), which should not be depressed by setting the child upon its feet prematurely; nor should a deformity of the feet be produced by shoes which cramp. However genteel a slender foot may look, an attempt to produce it, by wearing tight shoes, will not only cause great discomfort, but also a very ungraceful gait, and prove a great discount to personal appearance in several respects.

Fig. 17

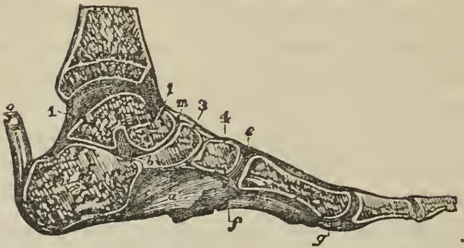


Fig. 17.—Section of the bones and ligaments of the foot and ankle. The figures refer to the bones, and the letters to the ligaments, except *o*, which is the "heel cord," a tendon of certain muscles.

117. The joints of the toes appear to be of very limited use; but upon further observation, they will be found to essentially aid in walking with ease, and if used as in case of some born without hands, become almost as perfect as the finger joints.

118. Considered as a whole, nothing could be better adapted to its purposes than the foot, when perfect; when imperfect, it is usually the fault of man. It was designed to be used with ease in walking, and to disperse the force which acts upon it when striking the ground.

119. Composed of twenty-six bones, more or less cellular internally, united by cartilaginous joints, so as to form an elastic arch, a step must be very unfortunate the force of which is allowed to act in a great degree even upon the knee. Yet by ligaments how strong the foot is made! A loaded cart has passed over it and caused but a severe bruise.

120. The perfection of all the bones in preventing the transmission of concussion, or the effect of blows, will be seen by placing several *solid* ivory balls in contact with each other and striking one with force—the last will fly off correspondingly; but interplace a bone of the foot, and the movement of the last ball will be but slight, on account of the spongy nature of the inside of the bone.

121. When the foot strikes the ground, the joints of the body are more or less flexed, and the force which acts upon the lower parts of the body is more and more dispersed in the direction of the dotted lines, Fig. 3. This, together with the nature of the cartilages furnished to the joints, especially the cushions of the spinal column, gives to the delicate and easily injured brain the most perfect security.

Fig. 3, B.

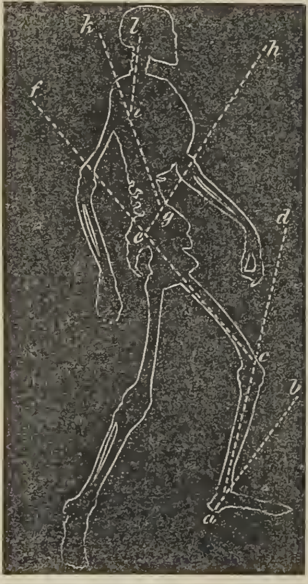


Fig. 3, B.—Represents the outline of Fig. 3. The dotted lines represent how the foot, when walking, is put upon the ground. The force acting on the heel, at *a*, is scattered, viz: a part of the force acts through the ankle and is lost in the direction *a b*, only a part of the force acting in the direction of the line *a c*; of this, only a small part will act in the line *c f*; and of this, only a part will act in the direction *e h*; of this, only a part in the direction *g k*; and of this, only a part in the line *i l*. In fact, these lines represent but a small part of the directions in which the force is scattered; for by the curve of the thigh bone, its neck and the connection of the hip bones with the back bone, as well as the continued curvature of this, the head is saved from the sudden jar produced when the body is as erect as it can be; for instance, when a misstep is made, or a person falling strikes upon his feet.

122. While the beautiful structure and admirable adjustment of the various parts of this framework excites in the mind the strongest feelings of pleasure, still greater satisfaction will be felt if we turn our attention to the wonderful operations which from birth till death *preserve* the perfection of this piece of mechanism.

123. First, the attention is arrested by the increase of size which is constantly taking place till the period of maturity, with the most exact regard to just proportions and the uses to be fulfilled.

124. This enlargement is accomplished by the gradual removal of every part, and the deposition of new substance in place thereof. (The teeth of the human species are an exception; they will be spoken of hereafter.)

125. The new deposition takes place within certain bounds, in accordance with the requirements of the parts; hence, if a boy be put to work early in life, the bones will become consolidated earlier; if worked too hard, deformities of the bones will be produced, that they may fulfil what is required of them, at an unnatural period of life.

126. Second; all through life even the hardest parts of the system are wearing out: in youth, in mature years, in old age even, it is so. The worn-out parts are continually removed and new parts laid down instead. In youth this process is most active, in middle age sufficiently so, in old age it takes place slowly. In early years, therefore, an injury is easily recovered from, in old age its cure is tedious.

127. The body, therefore, does not die, nor is it born once only; but, with the exception of some of its parts, is continually dying and being born, even in youth.

128. Of what consequence then, is this identical framework, which a few years ago we had not, and a few years hence we shall not have? Like the garments that cover us, "thread after thread it is worn away," but not like those does

any part become threadbare, for its perfection is restored continually by the deposit of renewing substance. The mind, then, is the man.

129. Third; when the bones are broken, a remarkably active condition takes place as a usual thing. The limb becomes exceedingly painful, so that a person may not move the broken part. Sometimes this does not occur, when the motions of the limb, which the patient will allow, prevent the parts from uniting, and cause them to be displaced. Under such circumstances it is usual for the surgeon to adopt such a course as shall produce the desired action and excite pain.

130. As genuine bone forms very slowly, an amount of cartilage is first formed about and within the bone, which supports the broken bones in their places, and allows the process of "knitting" to go on between the bones. After this is accomplished, the cartilage will be gradually removed and the bone left as before.

131. As, when a limb is broken, a person's health is not affected in other respects, he does not always appreciate the importance of observing the surgeon's advice, which seems unnecessarily strict. The splints are to be thrown aside, he thinks, when he can raise the limb without bending it or feeling pain.

132. If a limb be broken, and no surgical assistance is at hand, the limb is to be placed as nearly in a natural position as it can be, and slips of thin wood or the like, applied as ingenuity shall suggest, bound on, not very tightly, but so as to give general support, and padded, to obtain the purpose better. Trust chiefly to the painfulness of the part to keep the limb quiet, for bandages which would do this, would be likely to stop the circulation of blood. It will be best to wear the splints longer than necessary, rather than go upon the other extreme, as people usually do. Remem-

ber, that a part is not cured because it is desirable, neither will *opinion* alter the state of the bone.

133. With this view of the framework, the reader will appreciate the effect upon it of female dress, as usually worn, and of male attire, as sometimes worn. While yet an infant, the belt of the girl is pinned snugly, for the purpose of producing a "trim figure." Too often this is the case, even with the boy.

134. The ribs are not yet firmly fixed in their sockets, are easily bent, while the slightest pressure is sufficient to produce deformity of the pliable cartilages, which form the front part of the chest. There is no doubt, that the usual custom will lessen the size of the waist. But is this an improvement? (Figs. 18, 19.) If the reader disagree with the writer on this point, he cannot think the ultimate results favorable. (Fig. 20.)

Fig. 18.

Fig. 19

Fig. 18.—The form of the Venus de Medici; beautiful to the eye, graceful in movement, healthful, and long-lived.

Fig. 19.—The compressed chest of mistaken taste; pity-causing, ungraceful, disproportioned; productive of ill health, deformity, a sallow complexion, premature wrinkles, and untimely death.

Fig. 20.

Fig. 20.—1, 1 represents the spinal column or back-bone very much curved, causing the right shoulder to be very prominent.

135. Fig. 20 is of course an exaggerated view of the ordinary effect of tight dress, but worse deformities frequently occur. Within the ribs are found organs, which are both compressed and displaced by lessening the waist. To diminish the evil, and give these parts as much room as possible, nature causes the upper part of the chest to yield.

136. In the first place, this causes square shoulders, instead of the graceful "falling" shoulders so much admired; or the shoulders will be prominent—what is called "round," and much disliked. From the constant size and firmness of the liver, on the right side, while on the left the stomach is sometimes full, sometimes empty, the effect of pressure will be greater on the right side.

137. In the second place, there will be a greater "shrug" or projection of the right shoulder than of the left, also a displacement of the spinal column, towards the right shoulder. These deformities render others necessary, that the system may be balanced. The head is inclined to the left, while the back-bone, in the loins, is displaced in the same direction. The hips are distorted, and the heads of the thigh bones cannot be opposite each other. Can the form of such a person be beautiful, or the movements graceful?

138. During the day a person grows shorter, while the height is restored by repose during the night. A French physiologist says, a son of his, during a single night's dance, lost an inch of stature, which he regained in two days. This is owing to the elastic nature of the cartilages, especially those of the back, and the restoring processes which are continually taking place in all parts of the body.

139. To sit or stand, most of the time, with the back in a curved position, will tend to produce permanent comparative thinness of one side of the cartilage, and consequent deformity; while on the other hand, a variety of exercise in a variety of positions, will not only prevent deformity, but from use, give a suppleness, vigor, and health to the cartilages, which can be obtained in no other way.

140. To sit, stand, or lie, in almost any position which gives comfort, cannot be productive of harm, if other positions be frequently taken. No class of people are straighter than the tailor, who sits much of the time in a curved position; but knowing that the fit of his coat is an advertisement of his skill, as soon as he is off "the board" he straightens himself.

141. A continued crooked posture is not to be recommended, neither is a lounging attitude always to be chided. Deformity is frequently caused by nature, to prolong the life which tight clothing tends to shorten; it cannot therefore be remedied by the oft-repeated advice to "sit straight;" nature will remove the deformity as soon as the cause for which it was produced is removed.*

142. The ligaments, cartilages, and other parts are of

* Experience has testified, that the tight clothing, supports, and directions to "sit up," without exercise, heretofore used, with hard seats, straight-backed chairs, and no allowance of easy positions, have most signally failed to accomplish the desired object; and as it seems reasonable to trace the general deformity to these very things, will it not be well to try something else? A new course cannot be worse.

such a nature, when the system is "growing fast," that easy seats, chairs, rocking-chairs, sofas, and a reclining and supported position, will be often required, to give rest and strength. I never saw an Indian *sit* erect, and the cat and dog repose themselves much. It is neither the curved position which does harm, nor the erect position that gains benefit; but any position too often indulged in, or too long continued, produces evil results, while a variety of positions, and all kinds of exercise, give beauty and health to the form, and vigor and gracefulness to the movements.

143. If deformity exist, can the exertion of force merely, effect a cure? What will prevent the recurrence of the deformity, when the force is removed? Nothing. Experience has proved, that the end is worse than the beginning. The reasonable use of any part improves it; disease enfeebles it. Exercise, gentle but gradually increased, is the required means for curing deformities. Years of patient perseverance will sometimes be necessary, to gain the rich reward.

144. When force, supports, and exercise have been combined, to effect cures of deformities, the cure, if effected, should have been attributed to the exercise, which not only cured the deformity, but also overcame the effect of the force and supports.

145. Horseback riding is one of the best kinds of exercise, or riding in an easy carriage, the use of dumb-bells, the elastic exerciser, and other specific exercises which in the judgment of a skilful physician are best adapted to correct the deformity. The ordinary deformity of round shoulders, caused by neglect, can be corrected in a few weeks, by exercise every morning for five, ten, or fifteen minutes, with the perfect exerciser, dumb-bells, or throwing a chair around the head, and the like.

Section 2.—*Muscles, Tendons, &c.*

146. The muscles are what is usually called the lean meat. The tendons are the pearly white, strong parts, terminating the muscles, and connecting them with the parts upon which they act.

147. The appearance of these will be well understood by examining the "drum-stick" of a fowl, and the cords which extend to the claws, so amusing to children.—

148. If the cord upon one side be drawn, the claws will be shut; if the cord upon the other side be drawn, and the first slackened, the claws will be opened.

149. If both cords be drawn to an equal degree, the claws will be firmly held in any position where they are placed.

150. In the living bird, it is the contraction and relaxation of the muscles in the leg above, which draws the cords acting upon the claws, either causing them to move or retaining them in any desirable attitude.

151. The first use of the tendon is evident; for if the muscles had continued down to the foot, it would have been so clumsy as to render it unfit for use; and again, the fleshy muscle could not form so strong a unison with the bone, as to resist its own action.

152. The use of the muscles is also evident, viz. to produce motion of the various parts of the frame, and retain them in desirable attitudes; for though the ligaments are arranged so as to prevent motion in certain directions, they have been designed to permit it in others, flexion in the permitted direction being caused or restrained by the muscles.*

* The frame being perfect, in respect to its structure, a beautiful form and gracefulness of action depend entirely on the muscles. In this section, therefore, especial attention will be given to explain what is for the good or ill of the muscles; for it is not only proper, but our duty, to do all in our power to improve personal beauty, both because in all that sur-

153. To fulfil these duties, it is requisite that they be numerous, contract and relax with promptitude, and with a greater or less degree of power; that they should combine their action or oppose each other, or act in harmonious succession.

154. Their ability to answer these requirements depends upon their structure, number, size, their position and mode of attachment, the passage of blood through them, their exercise, and the action upon them of certain influences called nervous.

155. By nature, the muscles are perfect in all respects; but their condition depends so much upon their treatment, and this is so faulty, that they are usually very deficient in the fulfilment of their important duties.

156. *Structure.* This is seen by observing a piece of lean boiled salt pork, salt fish, or almost any cooked lean meat. It will be noticed as composed of fleshy strings, easily separated in one direction; in doing which, a very delicate sheet-like substance will be seen clinging to and uniting the separating parts, somewhat loosely with each other. This is called cellular substance or membrane.

157. With proper instruments, the fleshy strings so easily perceived can be subdivided, till those will be found not as large as a spider's thread. These are covered with a sheath proportionably delicate, which extends beyond the fleshy fibre, and with the cellular substance connecting the fibres, is condensed into tendon.

158. Hundreds or thousands of these sheathed fibres are gathered into a bundle, and covered with a sheath somewhat thicker than the first, forming what is called a fasciculus.

rounds us, and in the functions of the human system, we have evidence that the Creator intended every thing should be beautiful and attractive, and because what really improves or obtains beauty is equally influential in gaining and preserving health.

Few or many of these covered with a sheath, called a fascia, form a muscle. Several muscles covered with a sheath, called also a fascia, form the arm. Place the hand upon the lower arm, then open and shut the fingers, and various muscles will be perceived. The fascia is for the purpose of binding the fibres, fasciculi, and muscles together, when they contract; the advantage of which will be seen, when a person grasps his arm with the hand and thereby raises a greater weight.

159. The fibres in any fasciculus are parallel and act together; but the fasciculi of a muscle may be parallel or otherwise, and may or may not act together, or may act in succession. Thus some of the muscles are fusiform (Fig. 21).* By this arrangement, the attachments of the muscle occupy but small space, and the neat and commodious hand is moved with great power.

Fig. 21.

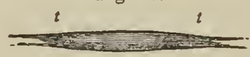


Fig. 21.—*t*, *t*, Tendons of a fusiform (spindle-shaped) muscle.

160. Some are radiate, as the sticks of a fan (Fig. 22). This is the case with the temporal muscle, the thin edge of which is attached to the side of the head, without deforming it, while as the fibres converge toward the lower jaw, they are received in a hollow of the skull. The trapezius is another example (Lith. plate 2). This was evidently thus formed with a view to convenience of action, as well as personal appearance. By its action the shoulder is drawn upward, backward, or downward, while by a successive contraction of its parts, a graceful rotary motion is given, which could not so well have been obtained in any other way.

* The stripes on the figures explain the direction of the fasciculi.

Fig. 22.

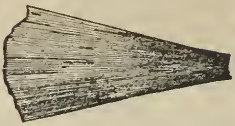


Fig. 22.—Fan-shaped, or radiated muscle.

161. In some instances the fasciculi are arranged upon one or both sides of a tendon, as the barbs of a pen (Fig. 23). By this arrangement a great number can act upon the same point. This arrangement is particularly seen in the leg, where a great amount of muscular substance must act upon small points.

Fig. 23.

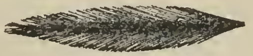


Fig. 23.—Penniform (pen-form) muscle.

162. In some instances the fasciculi form circular muscles, orbiculares, or sphincters (Fig. 24). These may partially or wholly close any opening which they encircle; the mouth, eyelids, &c.

Fig. 24.

163. In some portions of the body circular fasciculi are placed by the side of each other, forming a muscular tube (Fig. 25). By the successive contraction of these rings, any thing can be moved through the tube, as is exhibited in the neck of a horse swallowing water.

Fig. 25.

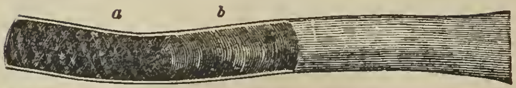


Fig. 25.—Section of œsophagus, or meat-pipe. *a*, *b*, Circular fibres. *c* Shows longitudinal fibres in another layer of the same tube.

164. Sometimes the fasciculi curve around, either in distinct layers or interlacing each other, so as to form a muscular pouch, bag, or bladder (Figs. 26 and 27). By the contraction of the muscular substance of a pouch, its contents will be expelled, as when the heart throws out its blood, or by the alternate contraction and relaxation of its various parts, its contents can be moved about in it, as when the food is digesting in the stomach.

Fig. 26.

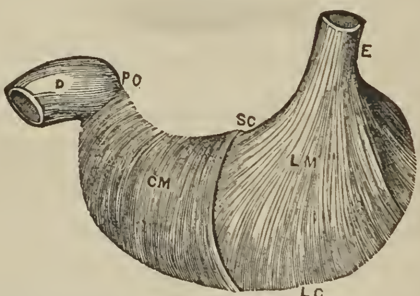


Fig. 26.—Stomach muscles. L M, One layer of fibres running in one direction. C M, A layer running in another direction. E, Lower part of meat-pipe. P, Pylorus. D, Commencement of second stomach.

165. The number of the muscles is about four hundred and eighty. The number will vary in different persons, and according to the plan adopted in counting them. Some persons divide a muscle into two, of which others make but one. Their number is such, that by the action of some one or its parts, or by the action of several or their parts, I know not a

Fig. 27.

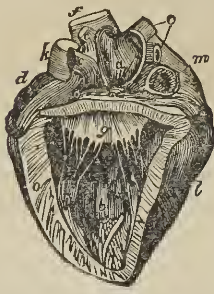


Fig. 27.—Represents the heart cut open, or rather, with a piece removed, the thick sides (*o n*) being composed of muscular fibres interwoven in every possible direction.

desirable motion that cannot be performed, muscles only being considered. The lithographic plates represent most of them.

166. *Size.* In size, the muscles are extremely various. The six which produce the lively motions of the eye, are very delicate and beautiful(Fig.67)while the glutei are very large. Where much power is required, the muscle will be large if there be no objection, but if a large muscle would produce deformity or render the part awkward in the fulfilment of duties, a small muscle will be found, and its power increased by the action of nervous influence upon it. In some constitutions, the muscles are naturally much larger than in others.

167. In every person the muscles will increase or diminish, within certain limits, by use or disuse; and as, in any given person, the larger the muscles the stronger, so ought every person who wishes strong muscles, to exercise the back and give vigor to the movements, to avoid the use of all supports which throw the muscles into disuse, enfeeble them, and produce deformity.

168. To gradually require more and more of any part is, therefore, a sure way to increase the power of performance, if in other respects proper attention be given.

169. *The positions* of the muscles can only be appreciated after a consideration of three kinds of levers, represented by Figs. 28, 29, and 30. An example of the first is seen in the common steelyard, and in the board used by children in playing *seesaw*. It requires a very heavy boy on the short end of the rail to balance a light boy on the long end, and the small boy moves through a long distance in the same time the heavy boy moves through a short space.

Fig. 28.

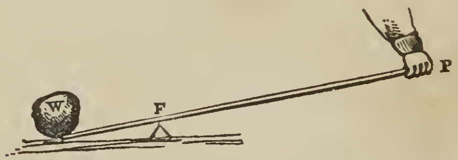


Fig. 28.—P, W, Lever. P, Power. W, Weight. F, Fulcrum.

Fig. 29.

Fig. 29.—F, W, Lever. P, Power. W, Weight. F, Fulcrum.

Fig. 30.

Fig. 30.—F, W, Lever. F, Fulcrum. W, Weight. P, Power.

170. The muscle on the back part of the arm (Fig. 31) corresponds to the heavy boy, and the hand to the small one. By a slight contraction of the muscle, the hand is quickly

moved through a long distance. Extent and celerity of motion is what the muscles are usually called to produce. But the muscle must be much more powerful than if the arm had extended in the dotted line (A E), and the muscle had been situated in the dotted lines (A S). But as a muscle can only shorten to a given degree, viz. about one-third its length, the motion of the hand would have been very limited. What an awkward thing the arm would have been!

Fig. 31.

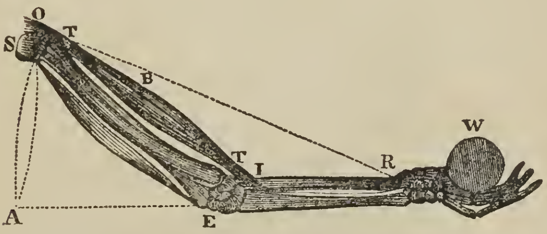


Fig. 31.—Represents, at S, the ball of the upper-arm bone, which extends to the elbow at E, from which the two bones (radius and ulna) extend to the wrist, to which the hand is attached, supporting the weight (W) T, T, represent the tendons, and B, the belly of the muscle upon the front part of the arm, attached at L to the lower-arm, and at O to the shoulder. On the back of the upper-arm is seen the muscle attached to the shoulder above, and to the projecting point of the elbow below. This point, it will be remembered, is a part of the lower-arm bone—the ulna. When, therefore, the muscle on the front of the arm contracts, the muscle upon the back must lengthen. When the muscle upon the front part of the arm contracts, the third kind of lever is represented; for the fulcrum is at the elbow, and the power, viz. the muscle, acts between the fulcrum and weight, and the nearer the weight the power acts, the easier is the weight raised. If, therefore, the power or muscle should act in the dotted line above the arm, a very small muscle would be sufficient to accomplish what is now done by O, I. But it would require as long to shorten the muscle an inch in one position as in the other; but the contraction of O, I, one inch, will produce extensive motion of the hand, while an inch contraction of the dotted line would raise the hand hut one inch. When the muscle on the back of the arm is contracted, a lever of the first kind is represented. The elbow is the fulcrum, and is between the power and weight; the action of the power, viz. the muscle on the back of the arm, draws the projecting part of the elbow up; and the other extremity of the same bone, viz. the wrist, must be carried down. If the point of the elbow projected to A, and the muscle acted in the direction of the dotted lines (S, A), it would have greater "purchase;" but if it contracted an inch, it would move the hand an inch only, while now, if it contract an inch, it will sweep the hand through great space, and of course, very quickly. The muscle also acts with greater power in the first part of its contraction, than when its degree of contraction is near its limit.

171. An example of the second lever is seen when a person attempts to raise a barrel of flour on to its head, by lifting at one end while the other is on the ground. The muscle acting upon

the heel (Fig. 32) is the power, the foot the lever, the ground whe e the toes rest the fulcrum, and the weight rests upon the ankle. Here, the greater the distance of the power from the weight, in proportion to the length of the lever, the greater the effect. If the distance be short, the power must be the greater. The muscles which raise the weight of the body, when we stand on tiptoe, must be very powerful, and they are so, both by size (Lith. plate 1) and the reception of nervous influence.

Fig. 32.

Fig. 32.—Represents the foot upon which the weight of the body rests through the bone (1), which may be called weight; M, a muscle, is the power, for by contraction it raises the weight; 2, at the great toe joint, being the place of the fulcrum.

172. An example of the third lever is seen when we attempt to close a window blind by seizing it near the hinge; the nearer the hinge the hand is applied, the greater the power required, but the less the motion. The part of the body most frequently described to illustrate this lever, is the forearm (Fig. 31). The muscle upon the front part of the upper-arm is the power, the joint is the fulcrum, the forearm is the lever, the hand is the weight. If the muscle had been attached at R, and been situated in the line T R, it would have been like putting the hand to the outer edge of the blind. The force required to raise the hand would be but slight; it would have

been raised, however, but slowly, and could have been raised but about one-third the length of T R.

173. Most of the muscles act disadvantageously as it regards expenditure of power, but the system is compact, beautiful, symmetrical, and the motions are performed with agility and to the extent required. In some cases the muscles act with the most complete advantage of position.

174. Some of the muscles, instead of acting between bones, are so situated as to act upon other parts to which they are attached. The "occipito frontalis" (Lith.) acts upon the skin of the head, moving the scalp, and is called a cutaneous or skin muscle. There are others of a similar character; some act upon the fascia, as the *Tensor vaginæ femoris* (Lith.), rendering them tense.

175. The tendons of certain muscles pass through loops or pullies, in such manner as to produce motion in a direction quite different from that in which the muscle contracts; the "superior oblique" of the eye is an example (Fig.67); the "digastricus," or "two-bellied muscle," is another instance—one extremity is attached to the skull just below the ear; it extends down to the side of the U-like bone at the top of the windpipe, where its central tendon is confined by a tendinous loop; its front extremity is then attached to the inner side of the jaw near the middle. Its use is to depress the lower jaw.

176. Bands confine the tendons of other muscles; for instance, the one about the wrist called an annular ligament (Lith.). A similar one is found passing from the inside to the outside of the ankle, in front, confining the tendons that raise the toes.

177. Some of the tendons pass through or under each other. The muscle which bends inward the last joint of the fingers, is situated below the muscle which acts upon the middle joints; the tendons of this last divide at their lower

extremities, one part being attached to one side of the bone, the other division to the other side, and the tendons for the last joint pass through between, whereby the fingers are neater and more useful. Again, the tendons of several muscles pass round certain bones, or are situated in grooves, as the tendon of the muscle on the outside of the fibula (Lith.), which passes down under the foot, and is attached just back of the great toe. Thus beauty and utility are every where combined.

178. Certain muscles pass across each other, as the tailor's muscle or sartorius, by which, with the action of others, the leg is drawn up, as when a tailor sits down on his board. The fasciculi of certain others are twisted, so to speak, and cross each other, as in the *pectoralis major* (Lith.). The contraction of the lower portion of this muscle would draw the shoulder down and forward, and the nearer it was attached to the shoulder, the more effectual; while the contraction of the upper part, would throw the arm across the chest, and the further from the joint, the more effectual. But the muscle must stretch down upon the arm but a short distance, or it would produce awkwardness. How ingenious, then, the contrivance which exists!

179. The position of the muscles is such, that motion is rarely produced by the action of a single muscle, but usually by the "composition of forces," which will be understood, if two boys attach two strings to a chair upon the floor, and then stand in front of it, some distance apart. If one only pull his string, the chair will be drawn toward him; if each pull his string at the same time, the chair will move toward a point between them, which will be nearer to him who exerts the most force. If more boys be furnished with strings, the comparison will be more perfect; and if one boy exert more force one moment, and another the next, the chair will describe a variety of lines.

180. The application of this principle in the action of the muscles is constantly required, but exceedingly difficult, as the force with which the muscle contracts must be almost constantly varying in the production of almost any motion.

181. The attachment of the muscles, except to the parts they are intended to act upon, is but slight, as can be seen, or felt rather, in the case of the neck cords, which hardly disturb the parts which surround them. They are, however, attached in the strongest manner at their extremities. Observe the force with which the muscle upon the front part of the arm acts without in the least injuring its attachment. By its connection with the lever, if one hundred pounds be raised in the hand, the power exerted by the muscle must be twenty-two and one-half times as great, or sufficient to raise a "heavy ton." Other muscles exert greater power still. I have seen a man lie down upon his back under a cart, place his feet against the axle, and by straightening his limbs raise fifteen hundred pounds' weight from the ground.

182. The position of the muscles is such, that if one contracts another must relax. When, therefore, we consider the effects of contracting a muscle or class of muscles, we must also consider the effects of relaxation of its opponents; and when we look for what will favor the contraction of muscles, we must consider what will favor the relaxation of its antagonists.

183. *Contraction and relaxation of the muscles are attended by a corresponding change of their substance.*

184. This is proved by the change which takes place in the blood passing through a muscle, by the increased appetite and requirement for food attendant upon action of the muscles, or by an examination of the muscles of an animal which has been driven or hunted to death.

185. If the muscle undergo a change, two things are necessary; that the portion of the muscle which by its action

has become unfit for use be removed, and its place supplied by new material. Hence the necessity for a

186. Free flow of blood. By the current of blood through the muscle the decomposed substance is removed, and the substance to recompose the muscle is brought.

187. Pressure upon any part checks the flow of blood, and of course must be seriously injurious to the muscles; to those of the young, for the muscles then need an extraordinary supply to cause them to grow, as well as to repair the effects of use, so do the muscles of all persons, that they may be endowed with the vigor necessary for the fulfilment of their duties.

188. Notice the muscles of the back (Lith.), and decide if the child can be gifted with a fine form, when the clothing prevents the free circulation of the necessary blood. Can the young lady be easy and graceful, when pressure upon the muscles of the chest, checks the flow of the repairing substance, without which the muscles must be colorless, flabby, and weak, and incapable of performing their duties?

189. Rubbing any part increases the flow of blood; hence the benefit of rubbing the muscles. It causes the changes to take place in them more speedily, and gives relief to fatigue.

190. Fatigue is for the purpose of warning us, when the muscle has experienced so much decomposition as to render it proper to grant repose and time for its repair; it is, therefore, a friend whose hints should be regarded. The farmer who uses stimulating drinks, for the purpose of overcoming fatigue, does overcome the feeling of fatigue, but benefits not the muscle. If he go on to labor, he injures the muscle and profits not himself, as attacks of rheumatism and the stiffness felt in his declining years will fully prove.

191. Rubbing the muscles relieves from fatigue, by benefiting them; hence why every laboring man should spend five, ten, or fifteen minutes, morning and evening, in doing

for himself what experience teaches is so beneficial to the horse.

192. Rubbing supplies the muscles with blood, which shall increase their size; hence why children should be thoroughly and daily rubbed from head to foot; for why should the colt, worth only a hundred dollars, be groomed so much better, that it may be fitted for the market, than the child, whose welfare is beyond price?

193. Rubbing supplies to the muscles that blood, by the action of which a fine, healthy condition is preserved; hence why those who wish to be graceful should rub the system from head to foot, at least once per day; for why should the animal which the young lady rides, have daily attention paid to him in this respect, that he may prance with ease and make a fine appearance, while she, whose beauty is so much more attractive, is neglected?

194. Rubbing supplies the muscles with the material which can restore their health and power of action. To the deformed, to the palsied, to those whose muscles are withered or shrunk from disuse, the hint is sufficient. To the positively diseased by palsy it may do but little good—it can do no harm.

195. Contraction and relaxation of the muscles has in one respect the same effect as rubbing, the blood-vessels being constructed, as hereafter described, so that the flow of blood must always be onward, and never backward. When a muscle contracts, its blood is pressed out from it; when it relaxes, there is a rush of blood into it; hence why the alternate contraction and relaxation are necessary; for a muscle remaining long contracted, is undergoing decomposition without receiving blood to repair itself. The severest fatigue is therefore felt, to compel us to desist, or the muscle would be affected beyond restoration, as has sometimes occurred, when a feeble person has been called up, to save his

property from fire—excited by the danger, he failed to heed, did not even notice the warning of fatigue, till exhausted, he was overcome, and years failed to effect a recovery.

196. In very rapid contraction of the muscle, a state approaching continued contraction is produced. The blood has hardly time to gush through the muscle, perhaps does not visit every part, before it is sent on by re-contraction. Hence why a horse bears better to draw a heavy load slowly, than a light load quickly. Stage horses improve in "muddy going," though longer on the road,—their muscles contracting slowly, there is time allowed for their repair.

197. Exercise improves the condition of the muscle, by causing its bloodvessels to enlarge, both transiently and permanently. There is a power operating in the healthy system, to adapt each part to the fulfilment not only of its ordinary, but extraordinary duties.

198. From what has been said, it is evident the muscles require more blood when in action than when in repose. The very exercise of the muscle answers the requirement in part; the increased action of the heart, as hereafter shown, is an advantage; but the bloodvessels of the exercised muscles are enlarged for the time, and by repeated exercise the enlargement is made permanent, though an additional enlargement takes place at the time of action.

199. To strengthen the muscles, therefore, exercise must be gentle, repeated often, and very gradually increased. If it be violent at first, the muscle is injured. Those who speak, therefore, but once or twice per week, feel fatigue, while those who speak every day find it a pleasure. The person who is deformed from weakness of the muscles, exerts himself, and finds no relief, but harm to follow.

200. The sick must be especially careful, for the power referred to, as adapting all the organs to their exigencies,

is feeble; and the muscles become strong *very* gradually in such a person,—it is an exceedingly easy thing to overdo.

201. But rest seems as necessary as exercise. It is evidently so, for repose is eagerly sought after vigorous action, and a sound sleep follows. Slight repose is necessary after each contraction of the muscle, that the blood may be allowed to flow through it and communicate vigor by renewal, but yet the decomposition does not seem to be entirely compensated.

202. When the system is "growing," rest seems especially necessary; nature causes it to be sought, and following her hints, the system will not be subjected to very arduous labor, and a reclining posture will be allowed. Alarm will not be felt if, at such times, the chest and head fall forward somewhat. This will be "outgrown," if no force, supports, or tight clothing be used, and a plenty of exercise in the open air be allowed. The power which acts upon the muscle to produce all these results, is called the

203. Nervous influence. Whether this be of the same nature, when we see it exerted on the heart and causing it to beat, as when we see its effect in the contracting muscle of the arm, and when its action is seen upon the bloodvessels of the muscle enlarging or diminishing them, is not known. Whether there be one fountain or several from which it is derived, is not known with certainty.

204. Some of its effects are directly influenced by the mind, some only indirectly. The muscles are therefore divided into three classes; those which in health are contracted by the nervous influence under control of the will, such as the muscles of the arm, and are called the *voluntary* muscles; those which are never directly acted on by the will, as the heart, and called the *involuntary* muscles; those over which the mind ordinarily exerts no control, but over which within limited bounds it can, as the muscles concerned in breathing, and called *mixed* muscles.

205. At present the muscles of the *first* class are under consideration. The nervous influence which acts upon them is derived from the brain through the nerves. To study these will therefore be the next step. But first, a view may be taken of the known effects of the nervous influence on the muscles.

206. Its first effect is to add immensely to the cohesive attraction of the substance of the muscle in one direction. Out of the body a muscle is separated by a small weight, but in life it is capable of exhibiting immense force without being injured in the slightest degree.

207. The degree to which a muscle shortens and the power which it exerts, depends not on its size, merely, but on the nervous influence it receives.*

208. Whether the relaxation of the muscle is an active operation, or takes place by the withholding merely of the influence which caused its contraction, is uncertain.

209. The action of this influence depends much upon habit, as is seen by rotating the shoulder by means of the "*trapezius*" (Lith.) upward, backward, and downward, and then trying to rotate it downward, backward, and upward. The *muscle* is as ready to contract one way as the other, but we are in the habit of exerting the nervous influence upon it only in one way. How awkward the combined movement of the fingers when the first tune is attempted on the piano—by practice how graceful!

* It has been somewhere stated, that if a small muscle be ordinarily called on to perform great labor, it is supplied with a large nerve. But we see every day, that a greater or less degree of nervous influence is exerted through the same nerve, and with the same instantaneous effect. Nor is there any proof or assertion, of which we are aware, that when a muscle increases to twice its former size and many times its former power, the number of nervous fibres passing to it from the brain are increased. My own opinion is, therefore, that if a nerve be distributed through a muscle so as to be able to cause decomposition and contraction of all its parts, it is sufficient, and that any amount of influence may be transmitted through it.

210. Many times indeed, muscles cannot act, because they have never been sufficiently *exercised;* but besides this, the perfection of gracefulness is the acquired ability to exert the *nervous influence* upon any muscle or part of a muscle, upon any class or parts of a class of muscles, instantaneously. It is this which confers the power of singing any combination of notes, or speaking any combination of sounds, whether of our own or a foreign land. It is an almost insurmountable task, but practice makes perfect.

211. The effect of habit is likewise seen in the muscles of expression, as those of the face (Lith.) are called; though at times every muscle of the body exhibits the fervor of the mind. Almost any state of mind will, from habit, exhibit itself in the constant action of certain muscles, even when this is not desired, indeed when a strong effort is made to prevent it. The miser, who spends his time at home in counting his money, will betray his avarice in his face, even when dropping his hypocritical alms in the church box.

212. A lovely expression is to be obtained only by maintaining a lovely state of mind. *Nature* never supposed a man would *be* one thing and wish to *appear* something else, but judged he would be proud of showing himself as he is.

213. As all real beauty is in the mind, and matter is nothing, except as we associate the action of mind with it; there is nothing so attractive, however bad the complexion or homely the features, as a face exhibiting an amiable disposition, a noble and cultivated intellect. The tinge of beauty on the cheek can be surpassed by the inanimate lily; the dentist can supply the deficiencies of nature as perfect in beauty as her own works; the sculptor can give us perfection of features beyond reality: it is the mind only which makes the "human face divine."

214. The muscles being thus dependent on nervous in-

fluence and the action of the mind, if the nervous influence be diverted to other objects, the muscles cannot contract with vigor, nor can they, without the *energetic* action of the mind. Those, therefore, who hope to gain benefit from exercise by merely exercising the body, while the mind is deeply engrossed with home or business affairs, will be disappointed. To labor or exercise in a way that engages the mind, and also produces a lively, agreeable disposition, is exceedingly important. A dull, compulsory walk, is not the thing.

215. The laboring man will also perceive that mental cultivation is important for him, if he would labor with success. He who reads two hours per day, and works eight, will accomplish more in a lifetime than he who labors ten, and does not devote any time to the improvement of his mind.

216. The voluntary muscles are also active involuntarily. That they *can* be so is evident from the twitchings seen in chorea or St. Vitus' dance, and in the convulsions of disease, lock-jaw, tetanus, &c. That they are is certain, as, if a muscle be cut, the wound gapes; if a bone be displaced, the greatest force to be overcome in "setting" it, is the involuntary action of the muscles of volition; if a person walk, stand, sit, or recline, or even repose in sleep, the constant involuntary action of the voluntary muscles is required to balance the system;—many other illustrations might be used.

217. Some suppose a certain degree of power of contraction resides in the muscle itself, which seems to be exhibited in the rigidity of the muscles after death. But, all things considered, every action of the muscle seems to be conferred by the nervous influence, and this I believe is the opinion of nearly all persons, and is proved by the effects of tobacco, intoxicating drinks, fear and other emotions of the mind, and of disease of the fountains of nervous influence.

218. The power and certainty with which the involuntary contractions of the voluntary muscles take place, seem dependent but very slightly upon habit, but upon the health of the system and its natural constitution; things which affect the condition and energy of the nervous influence. The power of exercising this influence may be classed as an instinct. The power of balancing the system, seems to be rather dependent on overcoming fear and trusting to the power which has been spoken of, and on strengthening the muscles, than on perfecting the action of the voluntary influence.

219. Habit has however *its* effect, either on the production of the influence or on its exercise; for a disease having existed, its symptoms continue after it has disappeared; as frequently a child cured of chorea continues to twitch, and other illustrations might be given. In such cases it is necessary to produce a powerful influence on the mind; and many wonderful cures effected by pills of bread or something not as harmless, found in the recommendations with which quacks gloss their advertisements, may be accounted for in this way.

220. The action of the muscles is facilitated by cellular substance, bursæ, and fat.

221. Cellular substance (Fig. 33) has been spoken of as found between the muscular fibres and fasciculi; it is also found between the muscles, between those and the skin, and between many other parts of the body.

222. Sometimes it is condensed so as to form a thick fascia, but usually it has the appearance exhibited between the muscles, and which its name indicates; viz., it is formed of very delicate membranes intersecting each other and forming cells, which communicate with each other and are moistened upon their inner surface, by a fluid very similar to synovial, but called serous fluid. From the fluid it forms, the cellular is also called a serous membrane.

Fig. 33.

Fig. 33.—A small portion of cellular substance or flesh, stretched so as to show its cells.

223. This fluid is continually formed and removed, as is the synovial fluid, and like it sometimes is wanting or accumulates; in this last case producing a kind of dropsy called anasarca, for which sometimes medicines, sometimes an operation called tapping, is required. The result of this shows the communication of the cells with each other; as an opening being made through the skin, the fluid from the entire limb is drawn off. It makes its way from one cell to another.

224. The rapidity with which this is formed is shown by the swelling of the feet, which will sometimes become quite "puffy" in a very short time, and again be reduced as quickly, though this is partly from the enlargement and diminution of the veins.

225. The cellular substance is seen and understood by the butcher who thrusts a tube into a piece of meat and blows the air into its cells, for the purpose of giving it a better appearance. The French, for a disease of the joints of horses, pass a tube through the skin and blow the air into the cellular substance of the entire body.* When accident sometimes injures

* One physiologist proposed to inflate the cellular substance of the body with hydrogen gas, that its buoyancy might enable a man to fly. A somewhat "flighty" idea.

the side of the chest and lung, the air which we inhale finds its way into the cellular substance and the whole body is inflated.

226. Its nature and position is such that it is admirable as a "packing," and allows the muscles to move over each other with the slightest friction.

227. The bursæ are bags, internally moistened with a fluid continually formed and removed, which is sometimes deficient, sometimes superabundant. In the first place, inflammation is soon produced; in the last, a "weeping sinew" is the result, and weakness of the part is soon complained of. It should not be neglected as usual, as the remedy is simple and can be applied by any physician, though it may require repetition when done in the best way. Or a person may himself lay the part affected, the wrist for instance, on his knee, and strike the bursæ with the back of a firm, heavy book, with such force as to break the bag and allow the fluid to pass out. This is usually sufficient, but if the sides of the bag do not from inflammation unite, but again distend with fluid, the same operation is to be repeated. Some prefer to pierce the bursæ and inject some irritating substance. Had I one, I should have it treated in this manner.

228. Being placed where there is liability to friction, their use is indicated. A large one is found at the elbow, beneath the skin; several are found at the wrist; one, of an hour-glass shape, is seen by pressing upon the edge of the palm of the hand, as the fluid from the front part is pressed back, and can be readily felt.

229. To the muscles fat serves as a packing, and to keep them warm when deposited between the skin and muscles; in which position it also relieves from the rigid appearance which the contracted muscles would otherwise present. Its other uses will be spoken of hereafter.

Section 3.—*The Brain and Nerves.*

230. The functions of the nervous system are numerous, but in this section will be considered only in relation to muscular action.

231. In this respect, the office of the nervous system is to produce nervous influence; to transmit this to specific parts, and to cause it to act upon them.

232. The places where it is produced are called nervous centres; the nerves are the means of transmission, and the extremities of the nerves, or an unknown apparatus at the extremities, are the means by which the nervous influence immediately acts upon the muscular substance.

233. *First*, The Nerves: These are white pulpy cords, reaching from the brain and spinal cord to every muscle of the body (Fig. 34). If minutely examined, every nerve is found to be composed, like a skein of silk, of threads, each of which might with propriety be called a nerve, but is usually called a nervous filament.

234. Each filament is composed of a sheath, filled with a pulp or jelly-like substance. Two or more filaments, situated by the side of each other and covered with a general sheath, constitute a nerve, which is, of course, larger or smaller, as it is composed of many or few filaments. The filaments are extremely minute, being finer than the finest thread of the spider.

235. As the destination of the filaments of any part is the same, they converge towards each other, forming the smaller nerves; which converging in the same manner, unite to form the larger ones. Thus are formed what are called branches and trunks. These are not, however, like those of a tree or stream, blended, or properly speaking, united, but in this wise: if ten branches be composed of ten fila-

Fig. 34.

Fig. 34.—In the upper part of the head is seen the large brain. In the lower and back part, the small brain is represented. Below this, is seen the commencement of the

ments each, the trunk will contain one hundred in its entire length, or till it receive additions from other branches, which will increase its number.

236. The general neurilema, or nerve-sheath, envelopes the filaments of the trunk and branches, as the bark of a leafless tree incloses the wood. An inflammation of this sheath or membrane, is supposed by some to be the disease, neuralgia; but it is probable, or even certain, that other conditions also produce that painful complaint.

237. In the course of certain nerves are found, what are called plexuses and anastomoses (Fig. 35). The lettered extremities represent the nerves coming from the neck region of the spinal cord (Fig. 34). In the plexus, it will be seen that filaments from the various nerves pass across each other, and unite with those from a different nerve. The figured extremities of the plexus are therefore composed of filaments from each of the lettered extremities. An *anastomosis* is a small plexus, and not, as its name signifies, produced by a genuine uniting of the nerves, or rather an opening of the nerves into each other. At either of these, the direction of the filaments is merely changed, and each one can be traced through the plexus or anastomosis. The object of such an arrangement seems to be, to allow a certain degree of influence to act upon any part, by uninjured branches, if a nerve be accidentally severed, and to allow the influence to act simultaneously upon different and perhaps distant parts, the harmonious action of which is required in accomplishing any object.

238. That the nerves are the means of transmitting the nervous influence, is proved by the effects of sections and

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spinal cord, enlarged between the shoulders and in the loins. From this, the nerves are observed extending from either side in pairs, the large ones, in the region of the thighs called the sciatic, passing down the lower extremities, being especially worthy of notice. In the loins and vicinity of the shoulders, the nerves are observed sending branches to each other, thus forming a *plexus*. As the nerves unite to form the cord, it is also observed that their course is very much inclined upward in the lower part of the back, and scarcely at all in the neck.

Fig. 35.

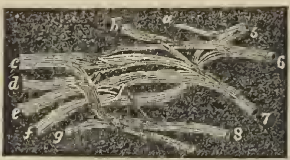


Fig. 35.—This represents a plexus, and the fact that the nerves do not strictly unite with each other, but that the filaments of one pass to be inclosed in the sheath of another, their course and neighbors merely, being changed.

compression of nerves. Experimental sections can be made in animals, and accident affords opportunity of observing the effects of section of human nerves. A lady in Concord, by falling upon a piece of glass, cut her elbow across what is commonly called the "funny" or "crazy bone," by which a section was made of the nerve which transmits influence to the muscles acting upon the little finger. She could no longer open it. If a divided nerve unite, as it usually will, in a longer or shorter time, control over the muscles is again restored. A section of any trunk exhibits an effect upon all the muscles receiving its branches.

239. The effect of compression, is exhibited when we strike the "funny bone" against the sharp corner of any piece of furniture. The little finger and side of the hand are not only numb in feeling, but are for an instant immovable by any influence we may try to exert upon their appropriate muscles; but as soon as the nerve has recovered from the effects of compression, the muscles are again subject to our command.

240. A large nerve, "great sciatic" (Fig. 34), in a part of its course, is so situated that it is sometimes compressed between an unpleasant seat and the hip bones. The effect produced is described by saying "the foot is asleep."* The

* This state of things is not produced by a stoppage of the circulation of the blood, as is usually supposed.

influence being to a great degree cut off from the muscles of the foot and leg, they are moved with difficulty, if at all.

241. A tumor sometimes grows in such a situation as to compress a nerve, exhibiting peculiar effects in the parts where the filaments of a nerve terminate. Removal of the tumor removes its effects. Disease of a nerve, and sometimes disease of the part through which the nerve passes, produce like effects, exhibited in the parts where the nerve terminates.

242. When, from any cause, control over the muscles is lost, they are said to be paralyzed, when perhaps *they* are perfect, and ready to act, if the influence were only exerted upon them. Hence, sometimes rubbing the muscles, &c., will produce a favorable, and sometimes no effect, the cause of their inaction being far distant from them.

243. How the nervous influence is transmitted through the nerve, what effect it produces on the nerve, or the nerve on it, or whether the nerve rapidly undergoes changes while fulfilling its duties, is not known. Our present ignorance of the intrinsic nature of the nervous influence and its mode of action, precludes us from arguing very successfully, as to what is or ought to be the condition and manner of acting of the nerves. The nerves do not seem to undergo changes very rapidly, as they receive comparatively but a small supply of blood. Hence they are seldom attacked by the inflammation which exists in parts which they traverse. This is another remarkable instance of the admirable arrangement which pervades the whole system.

244. Each nervous filament has the property of isolating, as the expression is, the influence transmitted through it; that is, through any filament of a nervous trunk an influence can be caused to act upon its appropriate muscle or part of a muscle, without any influence being communicated to its nearest neighbor.

245. This exhibits a marked difference between the nervous influence and all those things to which it has sometimes been compared, and with which some have thought it identical, viz., electricity, galvanism, magnetism, &c. These will pass from one filament to all the rest in the same nerve; and if applied to a trunk, will exhibit effects in the muscles of all its branches.

246. There seems to be no proof that the filaments of a nerve increase in number or size by use. Nor does there seem to be any necessity for such increase. For aught we know, the most delicate filament is sufficient for the transmission of ten times the nervous influence, if such an expression may be allowed, as is ever transmitted, when the most powerful exertions are made. Observe the almost superhuman force exhibited in certain diseases. Whether the influence can be transmitted with any more facility or rapidity, when it is done frequently, is not known. Action of the muscle is produced with more precision, alacrity, and gracefulness, when frequently and properly repeated; whether this depend at all upon an improved condition of the nerve, is conjectural.

247. As, however, the development and preservation of the nerves must depend upon an adequate supply of blood, it is presumable that rubbing and general exercise, which increases the flow of blood through every part, would be highly beneficial to the nerves. This would be especially the case, when, from disease, the action of any part is torpid; for then the restoration of the nerves thereof, must be very much hastened by accelerating the flow of blood, by frequent and brisk rubbing, particularly as the muscles of the part are incapable of effecting much by exercise. It is a general rule, that any part which receives but little blood in health, is very tardy in recovery when diseased, especially if the disease be of a low character. If, however, the dis-

ease be of an active character, and acute inflammation exist, so that rubbing produces acute pain, it should be dispensed with.

248. *Second,* The terminations of the nerves. The nerves are so exceedingly delicate, when they reach the muscles influenced through them, that the statements of authors in respect to their mode of terminating are very discrepant. Some suppose that the nerves arrive at a simple termination. Others suppose that the nerves terminate in loops, by which arrangement they suppose they can account for effects seen. Others again suppose that there is some peculiar arrangement at the extremities of the nerves, by virtue of which the influence derived through the nerve acts upon the muscle. Some suppose that a substance of a peculiar character may be discovered at the extremities of the nerves in the muscles. Others, and I believe correctly, think that when the filaments reach the muscles in which they terminate, they are connected with genuine branches, which are indeed parts of them, in such wise that the influence acting through a filament, acts through all these minute twigs, which increase and diminish in number with the increase or diminution of the muscle.

249. There must be something peculiar in the extremity of the nerve, and different from its remaining parts ; as the muscles traversed by a nerve will remain entirely inactive, while those at the extremity are violently contracted. The influence must be caused to act through a certain distance from the extremities, as these do not touch each other ; while, on the other hand, the sphere of influence must be very limited, as one fasciculus of a muscle may be brought into action, while others in contact with it are uninfluenced. The darkness in which we thus sometimes grope, should not discourage the student, nor dishearten the confidence of the reader ; but encourage the first to greater diligence in investigating a sub-

ject so interesting, the unfolding of which will prove so valuable to mankind, and enrol his name among those of whom all men speak with love and reverence; and assure the last, that much of the disease which the skill of the physician cannot prevent or cure, is owing, not to the inefficiency of science, but to our ignorance, which difficulty, we hope some day will overcome.

250. *Third*, The nervous centres: These will be found in the brain and spinal cord, as is proved by section and compression of nerves, reaching from those parts to the muscles, as before illustrated, and by the effects of disease of the brain and cord.

251. In the first place,—the cord and its protections. The back-bone, in which the cord is situated, is its chief protection. This is composed of twenty-four bones, called vertebræ, resting on the "sacrum," or sacred bone—so called from its being offered by some ancient nations in sacrifice.

252. These bones vary in size and thickness, in different parts of the back; in the loins they are very large and strong, presenting a great extent of surface for the attachment of parts. The front part of the bone (Fig. 36) is called its body. This is very conspicuous in the loins, growing less and less so, till we arrive at the skull. Between each two of these, except the two upper ones of the neck, is found a cushion of elastic substance, called fibro-cartilage. This is very thick in the loins, quite thin in the chest, and intermediate in the neck, according to the necessities of the part where it is found.

253. The hole (Fig. 36) assists in forming a canal called the rachidien, which exists in the entire length of the spinal column. The diameter of the hole varies in different bones, as may be seen by examining Fig. 37. The hole in each vertebræ is greater at its upper and lower edge than in the middle, as in Fig. 38. By this arrangement, when the back

Fig. 36.

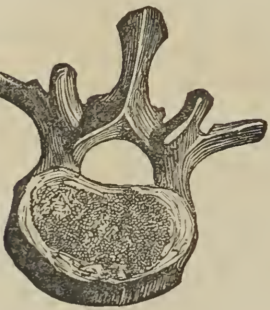


Fig. 36.—A vertebræ representing the body, the hole, the lateral (side) processes, and the spinous (spine-like) or posterior (back) process.

is curved, the contents of the canal are not injured by pressure upon the sharp edges of the vertebral hole, as would be the case if the hole had been as represented by the dotted lines (Fig. 38).

254. The projection at the back of bone, Fig. 36, and which is so distinctly felt in the back of any person, is called the spinous or spine-like process. A remarkable difference is observable in the arrangement of this, upon different bones. In the loins it projects directly backward (Fig. 40); and when the back is erect, there is quite a space between the processes of adjoining bones. In the chest, the process inclines downward very much, as seen by comparing Figs. 39 and 40; and when the back is erect, they almost or quite touch the bone below. In the neck, the inclination is less and less, as is also the size, till we ascend to the two upper ones, which are like those of the loins, but not as large, of course.

255. Two objects are gained by this admirable arrangement. Great extent of motion, forward and backward, is desirable, in the region of the loins and upper part of the

Fig. 37.

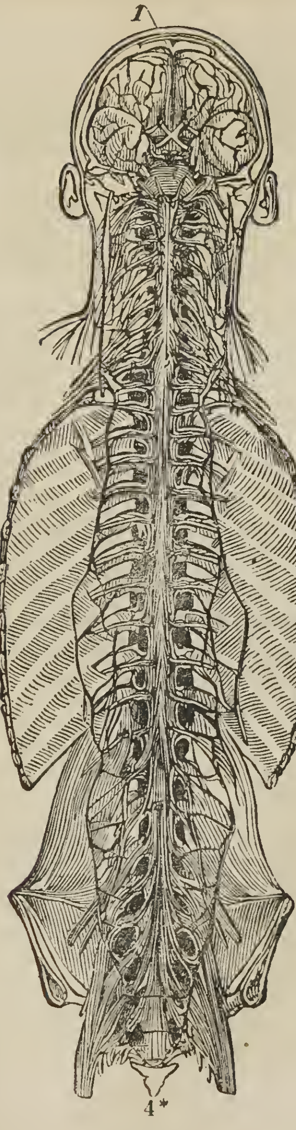


Fig. 38.

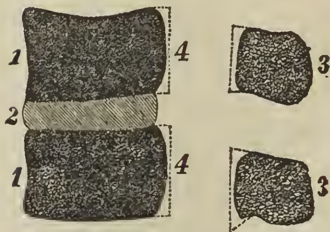


Fig. 38.—Is an ideal representation of two bones with their intervening cartilage (2) of the back; 1, 1, the bodies of the bone, through which a section has been made; 3, 3, are the posterior (back) processes of the same; 4, 4, is the canal in the back-bone, the surfaces of the bones upon either side being full in the middle (opposite 4, 4), and receding above and below. If the surfaces had been in the direction of the dotted lines, the canal would have been of the same size at the top, middle, and bottom of the bone; but now there is opportunity for the bones to bend without causing any angles in the canal, or lessening it, prejudicially to the cord.

neck; while a forward movement of the vertebræ of the chest should be very limited, and is made so by the position of the ribs; and backward motion, which would be still more deleterious, is properly restricted, by the inclination of the processes of the dorsal vertebræ. In the next place, the muscles attached to the spines, which are not inclined, have, as will be seen, a greater lever power, which is required for readily producing the desirable motions. The combination of great size, strength, and extent of surface; the action of the cushions, thick and elastic; the strong, perpendicular spines; and the conspicuous and proper enlargement of the

Fig. 37.—Represents a front view of the brain raised up, and the spinal cord,—the bodies of the vertebræ being removed. The black spots represent sections of the bone, between which the nerves are seen passing out. The greater distance of the spots from each other at different parts of the back, and the curve of the bone on the face toward the cord, exhibit the facility with which the back may be bent and the cord not injured. At the upper part of the cord, an enlargement represents the medulla oblongata (oblongated marrow); immediately above this, the cross lines show the pons Varolii (bridge of Variolius), as he suggested that the fibres of which it is composed might, like bridges, serve to connect certain parts of the two halves of the brain. Above this is seen the crossing of the nerves of sight, called the optic commissure, and above this, the deep fissure, found between the two halves of the brain. The continuous lines upon each side of the centre, extending from the upper part of the neck to the sacrum, in front of which they are united by cross lines, represent the situation of what are called the sympathetic nerves, upon the ribs upon each side of the back-bone; in their course, several enlargements called ganglions are seen, and they are represented as connected by small branches, with the nerves coming out from the spinal cord.

Fig. 39.

Fig. 40.

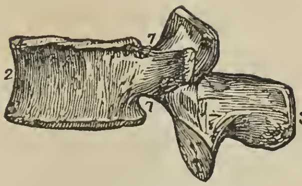


Fig. 39.—Represents one of the vertebræ of the back (a dorsal vertebræ). 2, The body of the bone. 3, The spinous process very much inclined down. 7, 7, The notches through which the nerves come out.

Fig. 40.—Represents a lumbar (loins) vertebræ. 2, The body of the bone. 3, The spinous process not inclined. 7, 7, Notches for the passage of nerves.

central hole or foramen at its upper and lower edges, in case of the lumbar (or loins) vertebræ, is only one among a hundred instances of the perfection which reigns through the whole system. Is not such beauty and perfection decided proof that disease and premature death is not in accordance with the intentions of Nature?

256. The prominences at the sides of the bone (Fig. 36) are called the lateral or side processes. They serve for the attachment of muscles, and in the region of the chest, afford support to the ribs.

257. Between each two vertebræ, at the sides, a hole is found, called the intervertebral foramen, or between the vertebræ hole. This is partly excavated from the lower bone of the two, but mostly from the upper. Through these holes the appropriate nerves find a passage into the rachidien canal.

258. The second protection is found in what is called the dura mater (Fig. 41). This is a dense membrane, about one-sixteenth of an inch thick, which lines the rachidien canal, being connected with the vertebræ at several points, but not very closely. Between it and the bones there is a portion of

oily or fatty substance, (during life it is between oil and lard in its consistence,) situated in its appropriate cells. This facilitates the movements of the internal cord.

Fig. 41.

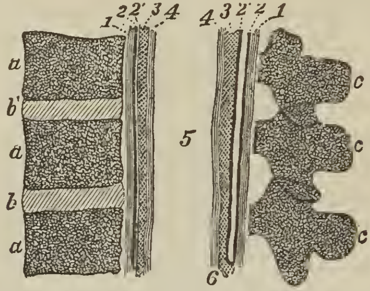


Fig. 41.—Represents the bodies (*a*, *a*, *a*) of three bones of the back, broken from the back parts (*c*, *c*, *c*), which are drawn away a little distance, that a view may be given of a perpendicular section of the spinal cord (5), and the parts (1, 2, 2, 3, 4) between the cord and the inner surface of the bones. 1, Dura mater. 2, 2, The two layers of the arachnoid represented as reflected at 6. 3, The coarse cellular substance occupying what is called the sub (under)-arachnoid space. 4, The pia mater.

259. Another protection is found in the arachnoid or spider's-web membrane. As its name indicates, it is exceedingly delicate. It lines and closely adheres to the dura mater by one surface, at first appearing like a part of it, and is reflected, as the expression is, so as to form another tube and cover the parts within it, to which it adheres. The two surfaces which are toward each other do not adhere, but are called free, and are moistened by a fluid called serous, existing in health only in small quantities, as it is formed and removed in the most constant ratio by the action of the membrane itself.

260. The side of the more internal arachnoid, toward the cord is connected with a cellular substance, existing between this membrane and the one which directly covers the cord. The cells of this being filled with fluid, distend the internal

arachnoid, and keep the two surfaces of the two arachnoids in contact, affording admirable protection to the cord.

261. Still another protection is found in the pia mater, which is the name of a membrane which immediately covers the cord, closely adhering to it, indeed rather compresses it, as when the membrane is cut, the cord protrudes.

262. From the sides of the pia mater, a portion called a process projects, and from this certain points reach as far as the dura mater. These form what are called the ligamenta dentata (Fig. 42). These support the cord, or retain it in a central position, allowing it, however, a certain degree of motion. The same purpose is subserved by a process, as it is termed, of the pia mater, which is attached to the lowest point of the rachidien canal.

Fig. 42.

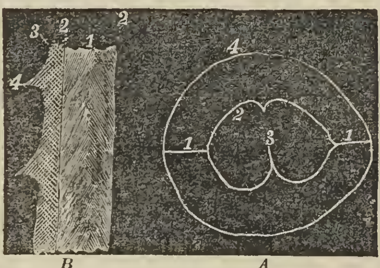


Fig. 42.—*A* represents (3, 2) a horizontal section of the cord and pia mater covering it, and at 1, 1, passing to the lining (4) of the bony canal. 1, 1, are called the ligamenta dentata, one of which is represented in *B*; which, by 1, represents a perpendicular section of the cord; 2, 2, the pia mater; 3, the ligamentum of one side, which at certain places extends to the wall in the form of points or tooth-like; hence the name dentata.

263. The cord extends from the skull to the lumbar vertebræ, when its large divisions form the "cauda equina," or horse-tail (Fig. 34). The position of its lower extremity varies with the posture of the back. In a stooping posture it is not as low as when the attitude is erect. The cord is

susceptible of being lengthened, and is stretched when the back is curved. Externally viewed, the cord is a white pulpy substance, so much resembling the marrow of the bones as frequently to be called the spinal marrow. It is not, however, a fatty substance, as the marrow, but is mostly composed of nervous fibres, like the nerves, many of which are indeed the same.

264. If a section of the back be made, as in Fig. 37, the nerves will be seen entering through the intervertebral foramina and the membranes of the rachidien canal, to unite with or form the cord. At the lower part, as in Fig. 37, or Fig. 34, the filaments of the nerve are seen inclining very much upward, after they enter the canal; but the upper nerves unite more horizontally with the cord; indeed, the upper pair rather incline downward.

265. If a transverse section of the cord be made, it will be seen (Fig. 43) to be composed of two halves, sometimes called two cords, united by a narrow band of white fibres, called a commissure. This accounts for the deep front and shallow posterior, dividing grooves seen in the entire length of the cord.

Fig. 43

Fig. 43.—Represents a cross, transverse, or horizontal section of the spinal cord, the dark half-moon shaped spots representing the gray substance.

266. Each half is composed internally of a gray substance, differing in its arrangement in different parts of the cord; its general appearance being that of a half-moon, with its convex side toward the other half, one horn reaching quite to the surface, and dividing each half into the smaller back

or posterior, and larger front or anterior columns, as they are called.

267. The gray has hardly as much consistence as the white substance. In great part, it seems to be composed of a granular substance, most nearly described by the word jelly; while the white substance appears to be mostly fibrous.

268. The use of this gray nervous substance, whether found here or elsewhere, is not known. But as it is easy to form conjectures, this has been done. Some suppose that it is the generator of the nervous influence, distributed through the white fibres, and consider that there is a nervous centre wherever this gray substance is found, and speak of collections of it, as brains. To confess ignorance is, however, far more honorable than to support a fallacy; beside that, it deceives ourselves; for truth is so lucid and necessarily supported by such strong arguments, it is at once recognized by the mind unprejudiced by adherence to invented theories.

269. Some have supposed the white portions of the cord are composed of the nerves, which enter the canal to pass up to the brain. In this case, the cord would be a very simple thing to consider, viz. a great nerve—the grand trunk of the body. But then, why such care in the arrangement of its protections? Why the gray substance? Why the enlargements of the cord in the region of the shoulders, where the nerves of the upper extremities come off; or in the lower part of the cord, where the nerves of the lower limbs leave the spinal marrow?

270. The best testimony and examination seem to prove that a portion of the nervous fibres commence at or in the cord, while another portion forms a part of the cord, being continuous from the brain; while it is not impossible, but altogether probable, that nerves commence at the brain and terminate in the cord, as will be made more clear hereafter.

271. In fulfilling one of its duties, the cord may then be

considered as a mere nerve, transmitting influence from the brain. In fulfilling another duty, it may be considered as a nervous centre, or as a congeries of nervous centres, where nervous influence is produced, and from which it is transmitted to the muscles.

272. If the head of a turtle be removed, and a coal of fire placed upon his back, as soon as the heat affects the cord, with harmonized action the legs scramble off with the body as fast as possible. If, however, the cord be destroyed, by thrusting a wire down the canal, nothing of the kind takes place. If only the front portions of the cord be destroyed, the motions of the fore-paws only cease. To show that there are several centres in the cord, various illustrations might be used; but space cannot be allowed to what may ultimately prove valueless.

273. In addition to what has been said, it may be well to exhibit in brief the opinions of the most eminent. Some suppose that the whole nervous system is continually charged with influence, which is continually passing to the muscles in a certain degree, and is increased when desirable. Others think the influence is produced at the end of the nerves, and is operated in some way, as yet incomprehensible, through the nerves; by some thought to be accomplished by a tremulous movement of the nervous filament, which nothing has proved to exist. Others think that a change is produced in the nerve, and propagated through the entire length of it; some thinking that this consists in a mere propulsory action from one particle to another, and some, that a decided change is produced in the particles forming the line of action. Most suppose that an entity is produced at the nervous centres, acting by certain, its own laws, through the nerves, with the quickness of lightning, and the perfection of results which mark the works of the Creator only. Some of these last consider that the influence is produced in

the brain only, from which it is disseminated; others, that it is produced in the cord only, from which it passes off, sometimes under the action of the brain, sometimes not. Some think there is but one grand centre in the cord; others suppose there are several. Some again think that both the brain and cord are centres, and some that there are several centres, either in the brain and cord, or cord and brain, or in both.

274. It may seem strange that there are so many opinions upon so important a point, but the opinions are not more diverse than the facts that can be advanced in their support; and no theory upon this subject has been advocated, which is not opposed by some fact. A large part, however, of the suppositions under ¶ 273, and many more like them, are evidently fanciful, and have few supporters. There is also one apology to be made. Scarcely any dependence can be placed upon analogy, the source of many fallacious arguments, for all animals are not operated upon in the same way by similar experiments; and a striking difference exists between effects upon other animals and man.

275. One theory is however worthy of more distinct notice. Sir Charles Bell supposed he had proved that the middle portion of the sides of the upper part of the cord were nervous centres. In these he thought the influence was produced which acts upon the respiratory or breathing muscles, and uncontrolled by the brain. My own opinion, and that of most, I believe, is in favor of the theory; but some do not regard it as correct.

276. Diseases of the spinal cord are various and very perplexing to the physician, from ignorance of the nature of the nervous influence, its mode of production and action, and the effects which its production will have upon the apparatus producing or transmitting it.

277. Its diseases and injuries exhibit paralysis, convulsions, cramps, lockjaw, shaking palsy, general weakness of

the muscles, &c. Some, perhaps all of these, may also be exhibited while the cord is, to all appearance, in a healthy condition. These exhibitions may be partial or general. One muscle, for instance, may be affected, or all below the injured point, or only the muscles of one side, according as a few filaments of the cord, the whole of it, or the half is affected.

278. One of the most simple ways of ascertaining the existence of certain common diseases of the back-bone or its contents, is to exert pressure along its extent, when pain will be felt if disease exist. In case it does, the earliest attention should be given, and the most assiduous care must be bestowed, for a long time, and in many cases it will be imperatively required. A person of real science, skill, judgment, and industrious patience to investigate and apply, is the only one who can afford the assistance which nature requires, and even then failure must be expected.

279. To *prevent* the recurrence of such disease is worth trouble. The attention may therefore be drawn to one evil very generally prevailing. The clothing of females is frequently so arranged, upon the lower part of the cord, as to preserve a temperature too elevated for its health; while in cool weather the upper part is too much exposed to suffer from a low temperature. This double cause acting upon the cord at the same time, and disturbing the circulation, must prove fruitful of the worst diseases.

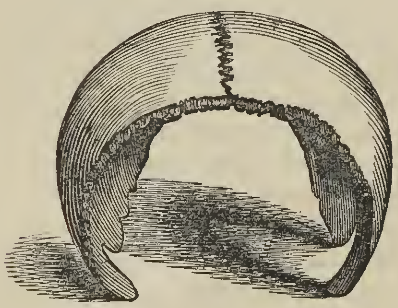
280. That rapid changes of the cord are produced in fulfilling its duties, can only be inferred from the large quantity of blood which circulates through the vertebral canal, and the liability of the cord and its appendages to inflammation. From all that we know of its duties, we can only infer that it should be supplied with a sufficient quantity of good blood.

281. In the second place, *the brain*. Its outer protection is the hairy scalp; beneath this is found a layer of fatty sub-

stance; then cellular substance, muscles, tendons, &c., when we reach the skull. These parts serve the double purpose of preserving the temperature of the head, and lessening the effects of blows. A lady of my acquaintance was once thrown from a gig against the sharp edge of a stone, her bonnet and knob of hair were badly cut; she was only stunned.

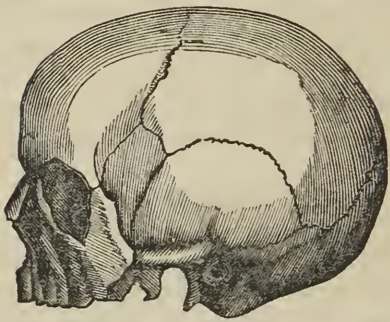
282. The general form of the skull has been demonstrated (Arnott's Physics) to be the best possible for resisting the effects of weight or blows (Fig. 44). The figure exhibits the arch found at the summit of the head; and any one may learn the strength of the arch, by observing the heavy burdens the arched bridge will support without yielding; or still better, by observing his own head. The immense blows the negro's skull is capable of resisting is proverbial.

Fig. 44 (A).



283. Concussion, or a severe jarring or shaking, seems to injure the brain more than cutting, or even contusion. Hence the impropriety of striking the head, even in the way of cuffing the ears. To prevent concussion, therefore, the utmost care has been taken. The skull is supported upon a doubly-curved column, composed of spongy bones and inter-

Fig. 44 (B).



placed cartilage, and attached in such a lateral manner to the hip-bones, that every advantage arising from a combination of the most perfect springs and an arrangement for the dispersion of force, exists therein.

284. And not only is this column connected laterally with the hip-bones—(if the thigh-bone had been placed directly beneath the back-bone, every step would have been shocking)—but the hip-bones are connected laterally with the thigh-bones. When the foot strikes the ground, these form an angle with the lower leg bones, which, with the arrangement of the joints of the ankle and foot, produce a perfection which leaves nothing to be wished.

285. The skull is composed of three layers; the outer and inner are called tables, the intermediate one has the name of diploe. The outer table being tough, is broken with difficulty, while the diploe, being of a spongy or cellular nature, deadens the jar an inflicted blow might produce in the outer table. The diploe is not found in early life, when the soft state of the bones render such a structure unnecessary; but as the bones grow brittle with advancing age, the diploe not only makes its appearance, but increases in thickness as the case requires.

286. The inner table is quite brittle and altogether averse to vibrating in harmony with the more external layers; and of course unharmonizing vibrations tend to neutralize each other.

287. When the skull is removed, the first internal protection is found in the dura mater, similar to that lining the spinal canal, indeed one is a continuation of the other. The dura mater of the skull, however, adheres closely to it, except when it dives down, as a separation between the halves or hemispheres of the brain, or where it comes forward underneath the back part of the upper brain, to serve as a shelf for its support.

288. In the first position it is called the falx, from its supposed resemblance to an ancient sickle (Fig. 45). It leaves the skull at the central line, and passes down nearly as far as the division of the brain exists, when it turns back, uniting with the first, till it arrives at the skull, when it goes on to line the rest of the skull. The falx is thus composed of two thicknesses, though at first it appears only one thing.

289. On the back part of the head is a ridge, extending from ear to ear. Corresponding to this, there is a ridge within the skull, from which the dura mater comes forward so far as to cover the cerebellum, when it folds back, adhering to itself, so to speak, to the ridge, from which it continues down upon the inner surface of the skull.

290. The dura mater is every where lined by the arachnoid membrane, which without close examination seems to be a part of it. As in the spinal canal, the arachnoid is reflected upon the more internal membrane called the pia mater. The two surfaces toward each other are in health moistened by a glairy fluid, which prevents their adhering. Like other serous fluids, it is in health removed in the same ratio as it is formed. As there is no fatty substance between the dura mater and its bony casing, as there is in the spinal canal, so

Fig. 45.

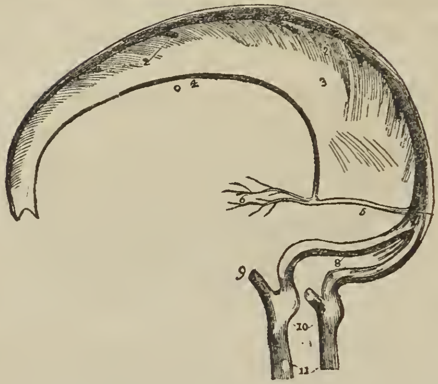


Fig. 45.—Represents the falx (3), situated between the two halves of the large brain. Upon the under and upper edge are seen veins, called in this part of the body sinuses. 2, 2, Branches opening into the upper sinus. 6, 8, Branches which drain the lower portion of the large brain. 8, Space between the two veins into which the great sinus divides. 10, 11, Two large veins which have wound round to the side of the bottom ot the skull.

there is no cellular substance between the arachnoid and all the upper parts of the brain; for the fatty and cellular substance are alike unnecessary. But at the bottom of the skull the cellular substance is very conspicuously developed, and supports the weight of the brain in a most admirable manner. The fluid contained in these cells communicates with that in the sub-arachnoid space about the pia mater of the cord, and as some think, affects the cord favorably, by adding its weight to the fluid of the canal. Not only the weight of the fluid in the skull, but a considerable portion of the weight of the brain, must be counted. Thus it is seen how beautifully the brain is placed, resting on the cellular substance and fluid of the sub-arachnoid spaces; it is unconnected above, but is allowed, without any friction or danger, a certain degree of movement in the skull, at the free surfaces of the inner and outer arachnoid.

291. The delicate arachnoid being removed, the pia mater is presented to view. This is a continuation of that in the canal, where it is quite strong and protective, as is required for the support of the cord; but at the upper regions of the brain it becomes exceedingly delicate, and seems composed almost entirely of bloodvessels of surprising minuteness. It closely envelopes the brain, following all the windings of its surface, and is much greater in extent than the outer membranes.

292. *The Brain.* What is usually thus called is composed of two parts, or as they are termed, the large brain or cerebrum, and the small brain or cerebellum. The last is found below the tentorium, in the lower and back part of the head; the rest of the head is occupied by the cerebrum.

293. The consistence of the brains may be compared to jelly, the small brain being a little more firm than the large. The brains therefore flatten as soon as removed from the skull, and must be cut with a very sharp knife if an examination be desirable.

294. The small brain, as seen in Fig. 34, is comparatively smooth on its external surface, and divided, as seen in Fig. 46, into two halves or hemispheres, by a shallow groove, which is apparent on the upper, back, and under surfaces. The color is in alternate stripes of white and gray. Its size differs in different persons, being usually larger in the female than in the male of the human species.

295. The large brain is composed of two hemispheres, separated by a deep groove, seen at 1, Fig. 37, which also passes forward from the back part, and backward from the front part of the brain, as seen in Fig. 47. In this groove the falx is situated.

296. The surface of the cerebrum is very uneven, being much like that of a peach-stone (Fig. 48). The prominences are called convolutions; the indentations, anfractuosities.

Fig. 46.

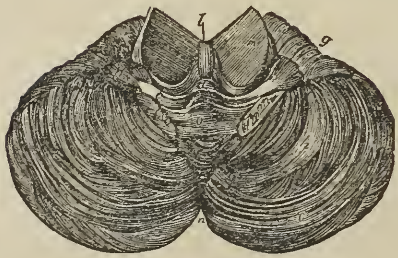


Fig. 46.—Upper surface of the small brain.

These pass quite deeply from the surface in many places, as seen in Fig. 47; where it may also be noticed, that convolutions and anfractuosities exist in the groove which divides the hemispheres. They will also be found at the base of the brain.

297. As has been said, the pia mater follows all the windings of the surface; while the arachnoid lies across, so to speak, from one convolution to another.

298. The color of the external portion of the cerebrum is very nearly like that of the ashes of "red-ash coal"—a reddish gray,—hence called the cineritious or ash-like part, the gray part, and is also called the cortical or bark part, because it surrounds the inner portion, as the bark of a tree surrounds the wood.

299. If a section of the cerebrum be made, Fig. 47, this arrangement will be conspicuous. The internal, white or medullary substance, is convoluted as the surface of the brain. It is indeed these convolutions, covered by the gray substance, which produce the convolutions of the surface. The thickness of the covering varies from a sixteenth to a half inch; differing in different parts of the same brain, varying still more in different brains: nor are its thickest or thinnest parts found in the same relative portions of different

Fig. 47.

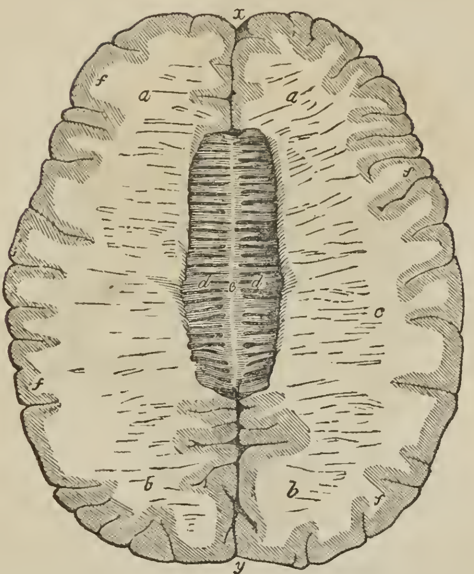


Fig. 47.—Represents a section of the brain on a level with the bridge, or corpus callosum (*d*, *e*, *d*); *a*, the front; *b*, the back; and *c*, the middle part of the white or medullary portion of the brain; *f*, *f*, *f*, *f*, the gray, cineritious, cortical or outer part of the brain; *x*, a deep fissure extending from the front surface of the brain to the bridge; *y*, a similar fissure at the back part.

brains, or indeed of the two halves of a brain. Neither does the size of the convolutions or the depth of the anfractuosities follow any rule. The depth or quantity of the white substance varies as much.

300. Fig. 47, represents a section of the cerebrum on a plane with the grand bridge or commissure which unites the two hemispheres. It is called the corpus callosum. It seems to be composed mostly of white fibres like the nervous filaments. Many theories have been advanced in regard to its use—probably all inventions.

301. If a section be made a little deeper, what are called

Fig. 48.

Fig. 48.—S represents the scalp, next to which is seen the skull or cranium (s, s). M, m, A part of the membrane lining the skull and covering the brain. L H, Left hemisphere of the brain. R H, A small portion of the right hemisphere seen beyond. F, The deep fissure in which the falx is situated.

the ventricles will be brought to view (Fig. 49.) These are frequently spoken of as cavities, which expression is apt to convey a wrong idea—as the sides of the ventricles are always in contact, except they are separated by unhealthy collections, which sometimes are to be found within them. The ventricles are lined with what is like, and called, a serous membrane—some consider it a continuation of the pia mater and arachnoid; some consider it has no connection with them. The ventricles have also several branches, called horns, leading off into different parts of the brain.

302. Forming the bottom of each ventricle, are found various parts of divers forms, sizes, and colors, helping to

Fig. 49.

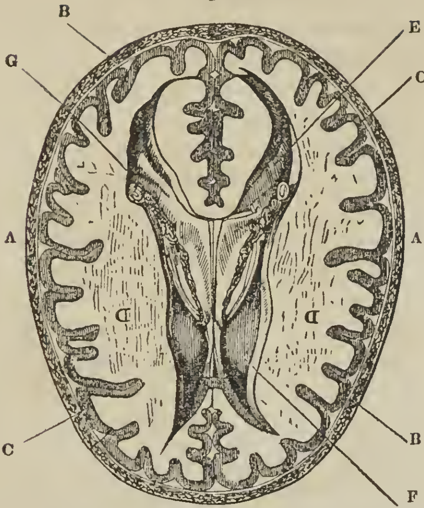


Fig. 49.—Section of the skull, A, A; the membranes, B, B; the gray substance, C, C; the medullary portion, D, D; the posterior horn, E, and anterior part, F, of the ventricles. The choroid plexus is seen at G. In the bottom and between the ventricles several parts are seen, but their use is not known.

make up the entire cerebrum. To name them and speculate upon their use, is all that science has yet done in respect to them. At the lower part of the brain, are also seen commissures; their utility is not known.

303. At the bottom of the skull, the brain is united with the spinal cord by an enlargement of it, called the medulla oblongata, or oblongated marrow. They are here also connected with each other. But examinations hereabouts have, as yet, proved very unsatisfactory; for barren description is very bootless. We can only infer, that there is free opportunity for communication between all the parts connected with each other; but how much influence they exert upon each other, and in what way, is unknown.

304. If a perpendicular section of the cerebellum be

made, a trunk of white substance is seen in the middle with branches extending on either side, from which smaller branches streteh to the surface. The inter-space is occupied by gray substanee—internally producing the appearance called arbor vitæ, or tree of life;—and externally, the striped appearance of which I have spoken.

305. The white substance throughout the brain is fibrous for the most part. A great number of fibres radiate from the medulla oblongata, upward and outward toward the convolutions. Some suppose that these arrive at the gray substance, and then curve around and pass over to the other half, and become continuous with its fibres, thereby forming the corpus callosum. This is by no means certain.

306. The office of the cerebrum in produeing motion, is unknown. The effects of experiments upon animals seem to prove, that the removal of large portions of the upper parts of the large brain, has no effeet upon the produetion of motion—frogs leap about, as if nothing had happened, and Magendie asserts, that earp swim as usual. But if certain of the lower parts of the cerebrum just in front of the upper part of the medulla oblongata be eut, the animal rushes forward or attempts to crawl if resisted, remaining in the attitude of onward motion.

307. The offiec of the cercbellum seems to be a little more decided. It seems to exert an especial influence in produeing thc involuntary motions of the voluntary museles. Hundreds of these are performed, of which wc take no notice. While addressing an audience, a person's mind seems to be abundantly occupied with the subjeet of his discourse and its delivery, and the balaneing of the body which requires the constant action of hundreds of muscles, seems no more to be controlled by him, than in case of him who walks while asleep. In thc case of every onc there are many movcments constantly produced, when hc is reclining

in the easiest position, and overcome by the soundest sleep. There is, also, awake or asleep, a constant action of the muscles, to a greater or less degree, as is evident from the gaping of a wound. That involuntary and unpractised influence may control the muscles, is certain—as we see evidence of it in animals that walk as soon as born.

308. Flourens observed, that irregular motions were produced as soon as an effect was apparent in the cerebellum of birds, with transparent skulls, which he had forced to take alcoholic drinks. If injuries be inflicted on the small brain, the like irregularities will result. If the portion of the cerebellum on the right side, near to the oblongata, be cut, the animal begins to revolve towards the left. If the similar part on the left side be cut, the animal revolves towards the right. Magendie says, he has seen these revolutions as rapid as fifty in a minute, and continue eight days. If the parts on both sides be cut at the same time, the animal is quiet, but unable to stand or walk.

309. If injuries be inflicted upon certain back and under portions of the cerebellum, the movements of the animal will be backward—birds will attempt to fly backward. There seem, as Magendie thinks, to be certain parts from which influence is continually exerted upon certain classes of muscles, the action of which will produce certain motions; but this is counteracted by the opposing action of another class. The effects of certain diseases, seem to prove the correctness of this opinion. Horses are sometimes so affected by disease that they will not, and apparently cannot, move backward. Most persons must have seen cats, when seized with what are called fits, fly with the utmost impetuosity round and round, or off in a tangent, regardless of obstacles. I have seen dogs, also, seized with the same impetuous and apparently involuntary influences.

310. By this time, the reader will perceive that no very

lucid description of the functions of the brain can be expected. The results of apoplexy, and other diseases and irregularities of the brain, convince us that healthy, vigorous action of the muscles, cannot take place without a healthy condition of the brain exist. The debilitating effects of alcohol, tea, coffee, tobacco, &c., upon the nervous system are, among other ways, exhibited by tremulousness of the hands and general weakness of the muscular system. Parts at the base of the brain—how numerous or how extensive we cannot tell—exert, without doubt, a constant influence upon the muscles; which, increased in its power, produces what may be called active contraction of the muscles. These parts, or the whole brain, act likewise upon the cord, influencing its condition; for in man the cord seems to be powerless, except connected with the brain: but influenced by this connection with the brain, the cord is the immediate source or centre from which the muscles are many times influenced. The office of the cord and brain, or of certain parts of them, seems to be different, or differently influenced, in man and animals; indeed, in different species of animals.

311. Whether the frequent and proper action of the brain, in producing muscular contraction, increase its size, has not been shown. Apparently, no effect of that kind is produced. If the same cause produce rapid changes of the brain, cannot be positively asserted. We can only infer that it does, from the fact, that in case of muscular action there is an increased flow of blood, through the head. As this blood returns of a different color and quality from what it was, a logical deduction may be drawn that the brain has undergone corresponding changes. On the other hand, an increased circulation of blood, as when alcoholics have been taken, produces increased muscular activity; so also in brain fever, or other diseases attended with active circulation of

blood through the brain. Apoplexy and opiates, attended with stagnation of blood in the head, not only producc stupor of the senses, but complete inaction of the muscles by any voluntary influence.

312. There seems to be no doubt, therefore, but a proper circulation of good blood, through the brain, is necessary for the accomplishment of its duties in producing muscular action. How admirable, that increased muscular action increases the rapidity with which the blood flows to the brain at the very time required! It hence follows, thai rubbing the body and general exercise of the system must be highly favorable to the brain. Hereafter it will be seen, that cultivation of the mind increases the circulation of blood in the brain, and thereby increases its efficacy in fulfilling its duties in connection with labor. Nor less important will be a cheerful disposition, for a merry heart sends the blood coursing briskly through every organ.

CHAPTER II.

THE ORGANS OF SENSATION OR FEELING.

General Observations.

It is exceedingly difficult to give a concise, yet plain description, of the apparatus, by means of which a person feels. If, however, the reader will carefully follow me, step by step, I will endeavor to explain, clearly as possible, all that is known of the manner in which he sees, hears, smells, tastes, feels pain, or has any kind of feeling or sensation.

It is evident to every one, that if his foot be hot, his mind knows it; or if his foot be cold, his mind knows that; or if the temperature of his foot be comfortable and right, his mind knows that. If his hand be cold, or hot, or comfortable, his mind knows it; but his mind is not in the foot or hand; for if either be removed, he has the same mind as before. Other like arguments would prove that the mind has its seat nowhere, except in or at the brain. How then can the mind know if the foot be hot or cold? If the foot be pinched, the mind knows that; if the hand be cut, the mind knows that, and if there be any thing, right or wrong, in any part of the body, the mind knows it at once. There must be something, therefore, which makes the mind know, at its seat in the brain, if the foot be hot or cold, bruised or sound; which makes the mind know the state of every part of the body. The organs or apparatus for producing sensations or feelings do this. They connect all parts of the body with the mind. Thus, no part of the body can be in any state, without producing an effect, through the organs of sensation, on the mind; hence,

313. The organs of sensation or feeling are of use, in the first place, to cause every state or condition of the body to produce on the mind an effect called a *sensation*.

314. If a particle of dust fall into the eye, it produces a bad state in this part of the body, and this will produce an effect on the mind, called a sensation. If the stomach be overloaded with food, an effect

called a sensation is produced on the mind; if a finger be cut, a sensation is caused; if the finger be pinched, a sensation of another kind is caused; if the finger be cold, still another sensation is produced. If disease attack any part, it produces peculiar sensations, differing according to the disease and the part affeeted. Thus, by the different effects or sensations produced, the mind learns every thing it knows about the condition of the body, and of course, the more perfect the effects or sensations are, the better does the mind know the condition of the body.

But again, it is evident to the reader that there is a book before him, his mind knows that there are letters upon its pages; his mind also knows the color, form, and odor of a rose; his mind knows that sugar is sweet and vinegar sour. How is this? His mind is at the brain. Does he say that light eomes from the book, and from its pages, and from the rose, into his eye, and thus he sees? But this does not explain the whole operation. The light only eomes into the eye, it does not go to the brain. Does he say, that he smells the odor of the rose, because it comes up into his nostrils? But the odor does not act on the brain. How then does the odor produce an effect on the mind? Does he say that he tastes the sugar, because it is put in his mouth? But the sugar dissolves in the mouth and remains there, except he remove it by swallowing or otherwise. How does he know that the ice he touches is cold? How does he know his foot is tickled? There must be means of connecting all parts of the body with the mind. Thus, when light acts on the eye, there must be something which produces a eorresponding effect on the mind. There must be something which makes the mind know when sugar is placed in the mouth, when ice touches the hand, or any part of the body. The mind knows these things by means of the organs of sensation. By the same means it knows all the effects which objects around us, both at a distance and near at hand, produce upon the body; thus,

315. The second duty of the organs of sensation or feeling is, to cause surrounding objects to produce on the mind effects, called sensations.

316. The roll of thunder and the flash of lightning, produce effects on the organs of sensation; and they then produce effects, called sensations, on the mind—which inform it of the approaching storm. Through the organs of sensation, or feeling, a piece of ice placed on the hand produces an effect, called a sensation, on the mind—which informs of its coldness: at the same time it produces another kind of sensation, which

informs of its weight, and still another kind, which informs of its color, size, form, &c. One person's voice produces one sensation, and the mind knows its friend; another person's voice produces another sensation, and the mind distinguishes its enemy. A rose produces a sensation of smell, that informs the mind of its odor; another sensation informs of its color; another of its delicacy, when touched. Camphor produces different sensations, of all these kinds, and thus reveals to the mind its qualities. Sugar produces sensations; vinegar, different ones. Thus by sensations, the mind learns all that it knows of the objects surrounding us—what and where they are. Indeed, knowledge of an object means, to know the kinds and degrees of sensations it is capable of producing in the mind, through the organs of sensation, and to this, is our knowledge of objects limited. The man born deaf, cannot know the important qualities or properties of the violin; for its music has never produced a sensation in his mind. He has a mind, but there are no means of connection between the violin and his mind, such that it can produce sound. Some of the organs of sense are wanting, or incapable of producing an effect on the mind. The portals of his ears are closed.

317. Objects surrounding us, do not therefore act directly on the mind; and consequently do not produce any direct effect, or sensation on the mind. They produce an effect on some part, or parts of the body, viz., on some of the organs of sensation; these produce an effect on the mind. The effect which objects produce on the organs of sensation, is called an impression.

We so constantly *say*, we feel this, or that thing—a piece of ice for instance—that we often *think* we feel the *ice*. But the ice touches the skin, not the mind; yet it is the mind that feels. What then does the mind feel, if it do not feel the ice? It feels the effect which the ice produces or causes to be produced, on the organs of sensation. If a string that I pull, be fastened to a boy's finger, he says, perhaps, I pull his finger. This is well enough in common conversation. It is not, however, strictly correct: I pull the string, to be sure; yet it is not I, but the string that pulls his finger. I make the string pull the finger. So the ice makes the body produce an effect on the mind; yet the ice does not directly act on the mind. I may cause a pin to prick a person, and he may say *I* am pricking him; but it is not correct. It is the *pin* that

pricks him. A ball may hit a person. He cannot properly say, the person who threw the ball, hit him.

318. The effect or sensation produced by the organs of sensation on the mind, when the object acts upon them, will depend, therefore, in the first place, upon the nature or properties of the object; and in the next place, upon the condition and nature of the organs of sensation.

319. That different objects would produce different effects on the body, is too evident to require remark. It would not be expected that boiling water and ice would produce the like effects on the body. But it is not so easily seen that the effect or sensation which the ice or boiling water causes the body to produce on the mind, depends on the nature and condition of the body, or of some of those parts of it, called organs of sensation. But if the hand be numb with cold, as on some winter's day, do things feel the same as when the hand is comfortably warm? If a person be sick, does not the weather feel more chilly to him than it would if he were well? Any person may try the experiment of putting one hand in hot and the other in cold water at the same time, and then plunging them in water neither cold or hot. This will not cause the same sensations to be produced through one hand as are produced through the other. But the water that acts upon one is precisely the same as that acting on the other. Why, then, the difference in the sensations? Because the condition of that part of the body through which one sensation is produced, is different from the condition of that part of the body through which the other sensation is produced. If a person have a severe cold, a rose does not produce its ordinary effect; not because the rose is at fault, but because that part of the body through which the sensation of smell should be produced, is changed from healthy to unhealthy. If objects act upon the body when it is not in a healthy condition on any account, the sensations which result must, therefore, be unnatural.

320. But the *nature* as well as the condition of the parts through which sensations are caused, determine the character of the sensation.

If a rose be put in the mouth, its odor does not produce any effect, because it is not the nature of the organs of sensation upon which the rose acts in the mouth, to cause any sensation of smell. If a bow be drawn on the back of a violin, it does not cause any music. To produce

that, the bow must be drawn upon the strings, for they were made for the purpose. The odor of the rose must for the same reason be applied to the nose, for the organs of sensation which connect between the nose and mind have been made so as to act on the mind when the odor of a rose acts on them. If the eyes be shut and the mouth open, light can pass into the mouth, but yet a person cannot see, because the organs that connect between the month and mind, if acted on by light, have not been made so as to act on the mind when light acts on them. But the organs connecting betweeu the eye and mind are acted on by light, and are so constituted that when acted on by light, they will act on the mind. Certain parts of the body will produce the sensation of tickling when acted on in a certain manner, which other parts will not. Thus the effect or sensation produced on the mind, by the action of any object upon the body, will essentially depend upon the nature or constitution of the organs of sensation acted on. From this paragraph it is also to be inferred that there are several classes of organs of sensation, differing from each other in their nature.

321. Observe also, that any state of the body does not act on the mind directly, but on the organs of sensation, which act on the mind.

An overloaded stomach does not act on the mind directly. To be sure we *say* this or that part, for instance a tooth, aches; but this is not so. The tooth acts on the organs of sensation, and they cause the ache.* If a particle of dust be in the eye, we *say* the eye smarts; strictly speaking it is not so; the eye acts on certain organs of sensation connecting between it and the mind; these produce an effect on the mind. Thus, any healthy or diseased part of the body produces effects on the organs of sense, connecting between the part and the mind, and these organs produce an effect, sensation, or feeling on the mind.

322. The effect or sensation which any part of the body will cause to be produced on the mind, will depend on the condition of the part acting on the organs of sensation, and upon the nature and condition of these organs.

* Perhaps the reader will object, that he really has felt the tooth ache; that the ache was in the tooth and nowhere else. The reason of this was, that we are so made as to feel the ache in the part where, as a usual thing, the cause originating the ache first acts. Sometimes it is not so; but this matter will be treated upon in its proper place.

323. That a healthy condition of any part of the body would produce a different effect on the organs of sensation, from that produced by an unhealthy state of the same part, or that two kinds of diseases of any part, acting at different times upon the organs of sensation, would produce different effects or impressions upon them, is too evident and too often experienced to require proof or remark. But it is important that it be as clearly seen, that the effect produced upon the mind depends also upon the nature and condition of the organs of sensation. Thus, in case of disease, when a person has chills, as they are called, he stands before the fire, but gains no comfort, though his body be heated. The diseased condition of the organs of sensation prevents them from producing the sensation of warmth in the mind, though they are acted on by heat. A person afflicted with neuralgia has a tooth drawn, in hopes of stopping the pain, but finds his hopes vain. It is the diseased condition of the organs of sensation which produces the painful sensation upon the mind. This is proved by the fact, that as soon as the condition of the organs of sensation is changed for the better, the painful are exchanged for agreeable sensations.

324. But the nature of the organs of sensation is still more worthy of notice. If the skin be pricked, pinched, bruised, burned, or the like, when in a natural or healthy condition, the organs of sensation, connecting between the skin and mind, will be acted on, and will also act on the mind, producing sensations. If, however, the tendon on the back of the hand, or any other tendon be exposed, it will be fouud by experiment, that it may be pricked, pinched, bruised, and even acted on by burning heat, and the person not know it. The organs of sensation, connecting between the tendons and the mind, may be acted on, for aught we know, but their nature is such that they produce no effect upon the mind. But if the tendon be twisted a very little, the mind will know it, for the organs of sensation connecting between the tendons and the mind have been made so as to be acted upon, and to act on the mind, under such circumstances. If a healthy bone be cut, the mind does not know it; because the organs of sensation connecting the bone with the mind have been so made, that if acted on, when the healthy bone is cut, they produce no effects on the mind. If, however, the bones be diseased or broken, the organs of sensation produce effects on the mind if the bones are moved in the slightest degree; for this is their nature or constitution—they have been so made. Persons have sometimes died of diseases of the heart, which they have had for years, and yet no one knew it till it was learned by post mortem (after death) examination.

The organs of sensation, connecting between the heart and mind, were not so made as to act on the mind in such cases. Reasons why these things should be so will be hereafter given. Thus the effect upon the mind, which any part of the body will cause to be produced, will depend in the first place on the condition or state of the part; in the second place, upon the condition of the organs of sensation, and in the third place, upon the nature of those organs. From the facts adduced in this paragraph it is also to be inferred, that there are several classes of organs of sensation, each gifted with different powers, by which each one becomes efficient in its own way.

325. The next question to answer, is, How do objects act on the organs of sensation, and how do they act on the mind? This is not known. But to form as reasonable a conjecture as possible, we must first notice, what is necessary to produce a sensation in the natural course, viz., mind, brain, a nerve, an organ of sense, and an object.

326. It is thus seen that several parts are necessary to form the organs of sensation, viz. the brain or nerve, and organ of sense; and in the order in which they stand in the preceding paragraph, they are between the object and mind. The mind is to be acted on, the object is to cause the mind to be acted on. It does cause the mind to be acted on, by acting on the organ of sense* which acts on the nerve, which acts on the brain, which acts on the mind. Thus it will be seen, that if the organ of sense be wanting as in Fig. 50, the object cannot produce an effect on the nerve, or if the nerve be wanting, an effect cannot be produced by the organ of sense on the brain, or if the brain be wanting, an effect cannot be produced on the mind, and of course, if the mind be wanting, no effect can be produced upon it. These things are proved in various ways. In the first place, to produce a sensation,

327. The mind is necessary; for if the mind be entirely occupied with any business, a friend may speak and his voice is not heard. Of course, it produces an effect on the organ of sense, and that produces an effect on the nerve, which produces an effect on the brain, but that causes no effect, which acts on the mind and is perceived.

328. The brain is necessary, as is evident when any derangement of it is produced by accident, disease or medicine. An insane person walks

* This has nearly the same name as organs of sensation, but is only one of the organs of any sensation.

barefooted on the frozen ground, and though frostbitten, feels no sensation. Opium, and its like, act on the brain, so as to prevent it from acting on the mind. The physician takes advantage of this quality of various medicines, to lull pain, as the expression is. Perhaps, and probably, an effect is produced on the nerves at the same time which prevents them from acting on the brain, as when pain is produced.

329. A nerve is necessary, as is proved by cutting the nerve, experimentally, in case of animals, and accidentally in case of man, and by compressing the nerve. A sensation is not then produced by any thing applied to the part, where the cut nerve commences; *e. g.*, the lady with the elbow cut, &c., mentioned in a former paragraph.

330. An organ of sense, is the name given to the part in which the nerve commences, and is of course necessary. It is sometimes necessary, as hereafter seen, to direct in a proper manner, the action of an object upon the nerve.

331. The necessity of an object, to produce an effeet on the organ of sense, or through the organ of sense upon the nerve, is too obvious to require illustration.

332. *It is important now, to observe, that if any of the organs of a sensation be diseased, the kind of sensation which an object will cause to be produced, will be affected thereby. If an organ of sense be diseased, an object will not produce the same effect on it as if it were healthy. If the organ of sense be healthy, but the nerve, or any part of it, unhealthy, the effect produced on the brain will be different from what it would be if the nerve were healthy; and if the effect on the brain be different, the effect the brain will produce on the mind will be different. So, also, will the sensation be unnatural, if the brain be diseased. That is to say, if the condition of the organ of sense, the nerve, or the brain, be changed, a corresponding effect will be produced on the sensation. When sick, therefore, things do not taste, smell, or feel as before; a very little light pains, or a very low sound distresses. It is very important, as hereafter seen, that the truths of this paragraph be fully appreciated and understood.*

333. A sensation is usually produced in the manner shown in the preceding paragraphs, but it is evident that if the brain act on the mind, a sensation will be produced, even if a nerve have not acted on the brain. So likewise, a nerve can act on the brain, and the brain will then produce an effect on the mind if the organ of sense have not acted on the nerve; and with like results the organ of sense can act on the nerve, if an object have not acted on it. In all these cases, when the mind perceives

a sensation, it will believe some object has acted on the organ of sense, because it is usually the case, and because it has been so made as to think it is so. Thus, by some disease of some part of the organs of sensation, a sensation is produced, and a person thinks a tooth is the cause, because the pain is like toothache, but when the tooth has been pulled, he learns that his idea was wrong. From a disease of some of the organs of sensation, a person will feel as if some animals, e. g. ants, were creeping on the skin, but it is not so, as he finds by examination; thus

334. The existence and character of sensations will depend, on the properties of acting objects, on the nature and condition of the organs of sense, nerves, brain, and on the mind.

The divisions of this chapter are therefore obvious.

SECTION 1.—*Sensations.*

335. Any effect produced on the mind, by or through any part of the body, is called a sensation.

Sensations are of many different kinds: of hunger, of thirst, of pain, of touch, of heat, of cold, of tickling, of nausea, of suffocation, of fulness, of sweetness, of sourness, of a rose, of camphor, of weight, of the various colors, of sounds, &c., &c.

Sensations of the same kind vary greatly in intensity. When of such a degree, as to be quite noticeable, they are called feelings. If the weather be perfectly agreeable, it is usual to say it produces an agreeable sensation, but if it be cold or hot, the usual expression is, it *feels* cold or hot. That is to say, a strong sensation is called a feeling.

336. Sensations may be divided into two grand classes, pleasurable or delightful, and unpleasant or painful.

337. Pleasurable sensations, when of a high degree, are called delightful feelings. They are for the purpose of rewarding the mind, for the care it has taken of the body, and inducing a continuance of the same care.

338. Pleasurable sensations are produced by the healthy condition and by the proper action of any part of the body.

A healthful condition of any part of the body, causes the organs of sensation to produce in the mind that peculiar and desirable sensation, difficult to describe, but which every one has experienced, when he says I feel well. The healthy exercise of any part increases the same sensation. The healthy exercise of the muscles is productive of great pleasure. He, therefore, who pursues a sedentary life, fails to enjoy all that class of delightful sensations which make happier the life of him who, by daily exercise, improves his muscular system. He not only, day by day, enjoys the sensations attendant upon the action of his muscles but fits them to increase the pleasures they are bestowing. For a full, healthy, daily exercised muscle, causes much more pleasurable sensations, and for a longer time, than the inefficient, feeble muscle. There is, therefore, pleasure in labor; not in the fatigue of laboring too long, but in labor, such as a man ought to do. The often exercised ear, adds a double charm to existence. The sensations it wakes up, thrill the soul, almost to ecstasy. The sensations caused by light, acting on the eye, are highly pleasurable. The mind, imprisoned from the action of light, and shut out from all the delightful sensations it causes, soon feels a gloom all other sensations cannot entirely remove. The balmy air of spring time or summer, wafted around us, and bearing to our nostrils the sweet fragrance of the scented fields, acts so genially upon the body, that the mind is satisfied with the delicious sensations it produces. The organs of digestion, while acting to prepare the food in the mouth, or after it is swallowed to the stomach, add much to the gratifications of life. Nor is there a small degree of pleasure felt, when, after proper action, the exercised organs are allowed proper repose.*

* I cannot help transcribing from a book, so common, on account of its value, that perhaps a reference will be thought sufficient; but Parker's Exercises may not be known to every one, and the passage will bear more than one reading:

"The words commonly used to signify diversion are these three, namely, relaxation, amusement, and recreation; and the precise meaning of these words may lead us to very useful instruction. The idea of relaxation is taken from a bow, which must be *unbent* when it is not wanted to be used, that its elasticity may be preserved. Amusement literally means an occasional forsaking of the *Muses*, or the laying aside our books when we are weary with study; and recreation is the refreshing or recreating of our spirits when they are exhausted with labor, that they may be ready in due time, to resume it again.

"From these considerations it follows that the idle man who has no work can have no play; for, how can he be relaxed who is never bent? How can he leave the Muses who is never with them? How can play refresh him who is never exhausted with business?

339. Pleasurable sensations dissipate melancholy, remove oppressive feelings, excite the action of the system, assist digestion, tend to improve health, and lengthen life.

The physician recommends to the low-spirited to travel, where new and pleasurable sensations and a variety of them will be produced. "The smell of the fresh air," says the invalid, "makes me feel better." The odor of the preparing food, if agreeable, excites the appetite; the taste of relished food causes a free flow of saliva into the mouth, and a free flow into the stomach of fluids necessary there, for a further preparation of the food. It is important, therefore, that we cultivate an appetite for wholesome food, and by exercise produce a relish for it; for the agreeable sensations then caused, will cause the food to be more readily and perfectly digested. Indeed, it is important that we cultivate all our organs, so as to realize the greatest possible variety and the highest possible degree of pleasurable sensations.

340. It must not hence be inferred that *all* causes of pleasurable sensations are productive of health. Some things cause pleasurable sensations at first, but afterwards very unpleasant sensations.

Man has been gifted with reason and intelligence, the cultivation of which is attended with a far higher degree of pleasure than is produced by exercise of the body. If he cultivate these by acquiring knowledge,

"When diversion becomes the business of life, its nature is changed; all rest presupposes labor. He that has no variety can have no enjoyment; he is surfeited with pleasure, and in the better hours of reflection would find a refuge in labor itself. And, indeed, it may be observed, that there is not a more miserable, as well as a more worthless being, than a young person of fortune, who has nothing to do but find out some new way of doing nothing.

"A sentence is passed upon all poor men, that if they will not work, they shall not eat; and a similar sentence seems passed upon the rich, who, if they are not in some respect useful to the public, are almost sure to become burthensome to themselves. This blessing goes along with every useful employment; it keeps a man on good terms with himself, and consequently in good spirits, and in a capacity of pleasing and being pleased with every innocent gratification.

"As labor is necessary to procure an appetite to the body, there must also be some previous exercise of the mind to prepare it for enjoyment; indulgence on any other terms is false in itself, and ruinous in its consequences. Mirth degenerates into senseless riot, and gratification soon terminates in satiety and disgust."

he will learn what things he may use, and how he may use them, so as to promote his immediate and ultimate happipess. The child, finding the seeds of the thorn-apple, and being ignorant of their quality, eats many of them and dies. A person ignorant of the nature of henbanc, cultivated the plant by his door, because he thought "the berries so pretty." Thcy were equally attractive to his child, which not only looked at them and picked them, but ate them ;—it was made very sick. A child cries for sweetmeats, which the mother, not regarding sufficiently the ultimate good of the child, allows it to have ; sickness, fits, convulsions, &c., follow ; while those of more knowledge, know it their duty, but still more feel it their pleasure, to watch the child till old enough to heed instruction, when they carefully teach it to avoid trouble-causing things. The young man who sips the enticing wine, wishing to enjoy the hilarity it will produce for the moment, will learn, when the poor-house is his prospective home—when his constitution is broken down, health and friends gone, and he a disgrace to himself and mankind—that many times "present pleasure is future pain." The oyster or other supper may make the passing hour more convivial; but a disturbed sleep and breakfast without appetite, and ere long a dyspeptic stomach, will teach a person that man cannot long be affected with pleasurable sensations, without he gain knowledge, and practise accordingly.

341. Pleasurable sensations tend to improve the disposition.

The child's mind should therefore receive a great variety of sensations—all those kinds which will not prove harmful in the end. It should be taught to love the flowers, for their beauty and their odor, and to be charmed with the scenery of nature. When very young, its mind should be occupied and its attention taken up with all the sensations produced by exercise, by new sights and sounds, by playthings, by songs and music—whatever will interest it, without producing any harm. Its mind is almost a blank, has scarcely a thought, is almost wholly dependent on sensations produced through its organs of sensation, and *they* have not yet become full and perfect. If it have no other sensations, it will desire those which are produced by eating or tasting; for from the first moment the infant mind wakes to intelligence, it will not be satisfied, without its attention be occupied with something. If the child desire to have some sensation produced which is harmful, its attention is to be occupied with some other sensation which will make it forget its desire. If the child's desire be denied, without its attention being occupied, it will fret, and its

disposition will be injured; but if its attention be called off by some new sensation, which is not harmful, no fretting is produced, *e. g.*, if a child desire sweetmeats, and they are put out of its reach and left where it can see them, and nothing more done, it will have a cry; while if some plaything be presented before it, or it be asked to go and walk, or in any other way, if its attention be occupied and sensations produced, while the sweetmeats are put out of its sight, the child will remain pleasant. It is hence seen how judicious it is to cultivate our physical systems in such a manner, that all proper sensations shall be produced in an intense degree; for though the pleasure of taste and smell, of touch and muscular exercise, of sight and hearing, may not rate with the results of mental cultivation, they fit the body to better serve the uses of the mind; they soften the disposition, and make us love better, ourselves, our fellow-men, and the world around us, which is so pleasure-giving to the healthy mind in a healthy body.

342. Pleasurable sensations produced by objects, render them attractive to the mind.

Hence persons may not only produce a very favorable *first* impression, but continue to render themselves agreeable, by dress and graceful manners, and by ministering to the sense of hearing, taste, and smell. The ear is beguiled by the silver tones of the voice. The good housewife retains the love and affection of her husband, by always meeting his appetite with delicious food. Many a heart has been ensnared by the fragrance exhaled from a bouquet of beautiful flowers, arranged by still more beautiful hands. Let not these little things be spurned. We may love a person for his good-nature, and admire his intellect, who is clownish. The careless woman may be the idol of her husband, for she may have excellent traits. But sensations must be produced on every mind, and they must please or displease. True, habit effects much; but God has intended that every class of the organs of sensation should be productive of sensations, and he will not allow his laws, even of the most minor character in our eyes, to be trampled upon with impunity. If one sensation only, displeases, it is so much for the other sensations to overcome. It will not be fruitless, therefore, to study the means by which sensations are produced and perfected, as we may thereby be able to make ourselves happier, and capable of rendering others happier.

343. *Unpleasant sensations.* When these are intense, they are called painful. They are for the purpose of warn-

ing the mind when the body is exposed to danger, or is actually injured. The causes which produce them may be considered under three heads.

344. First. Unpleasant sensations are produced when any part of the body is not used or exercised as much as it should be.

If the muscle be not exercised, an uneasiness, a discontentedness, a dissatisfaction with one's self, with the world, and with every body in it, is produced; sensations difficult to describe, and still more difficult to bear with a pleasant spirit. It may be called an appetite for the exercise of the muscles. The lover of music has often felt the unpleasant sensations produced by want of exercise of those organs which cause sensations of musical sounds. He has often exclaimed, "I feel hungry for music." This feeling is not altogether of a physical nature, if I may use such an expression. These unpleasant sensations are felt, because it is harmful to a person to have the organs causing such sensations, remain longer without exercise.

345. Second. Painful sensations are felt when any part of the body is over-exercised or over-tasked.

If the muscles be over-exercised, they first produce weariness, then fatigue, then exhaustion. The slightly unpleasant sensation of weariness is to warn when the muscles have acted as long as is for their good, and require rest. This sensation ought never to be increased to fatigue, much less to exhaustion; for then the muscles suffer, and sometimes beyond restoration. Persons have been so much excited by a fire, which was destroying their property, as to work on without heeding, or indeed feeling the sensations which would have warned of danger, till exhausted by labor, they have sunk down, never more to recover perfect strength. Whoever, therefore, takes alcoholic drinks or other poisons, that they may act on the brain and prevent the sensation of weariness from being produced, does himself harm. He *ought* to feel that he has done enough. The poison does not improve the muscle, and if he go on to labor, he will lay the foundation for rheumatism, and many other complaints. The housekeeper, who, tired, thinks to relieve herself by a cup of tea, and then go on, and finish her work, exhausts the system, and if she do not feel the exhaustion, produces at last a sick headache or like evil, lasting for days, perhaps. Too long-continued action of any organ, exhausts its power: an approach to this is notified by unpleasant sensations.

346. Third. Painful sensations are produced, when any part of the body is affected by accident, or is suffering from disease.

When the body is in the immediate vicinity of danger, a strong sensation of alarm seizes the mind, and impels it to care for the body. Some might say that this was wholly the operation of the mind. But if a very young child be raised, and then brought down quickly, as if it were falling, it will be seen, by its outstretched arms, to be in alarm. It has never yet fallen, and knows not that harm will follow, but a sensation is produced by certain organs of sensation, which have been made to act under such circumstances. It has also been shown that some parts did not produce pain under those circumstances, that caused others to produce pain. The reason for this is now seen. The skin produces pain when it is acted upon in any injurious way, because it is the outpost of the body; but why should the parts within, be painful when pricked, cut, etc.? The skin must be injured before they can be, and if it give warning that is sufficient. But the tendons are exposed to the danger of being twisted, without the skin being injuriously acted on; it cannot give warning therefore. Hence the tendons do. The bones become painful as soon as broken or diseased, because the splints and bandages of the surgeon cannot be applied so tightly without stopping the circulation of the blood as to keep the bones perfectly quiet; the person would many times use the bones before they had fairly recovered, if they were not painful. When they are not so, the surgeon is usually under the necessity of making them so, that the pain may assist his splints and bandages, loosely applied, in keeping the bones quiet and the person from using them. If an ulcer be upon the hand, it can be covered, and allowed rest, but if disease affect the lungs or heart, they must be kept in action, that life may be preserved. If they were painful, as it is best the hand should be under like circumstances, the pain would wear out the life of a person, much before it now terminates. When pain does exist, the kind of pain and degree of it, is very useful also in enabling the experienced physician to determine where and what the disease is. Hence the difficulty of determining with accuracy the disease of any part, when it is not the cause of any pain, and the diseases of children who cannot describe the pain felt; more especially when so young that their countenances do not at all express the kind of pain they are suffering. Thus pain is a great blessing; and when it does

not exist, as it should, instead of rejoicing, the physician sets himself to produce it, by, for example, rubbing the bones together, etc.

It is to be noticed, however, that sometimes, as far as we can now see, pain is produced without a good result, since it is very exhausting and without any apparently good effect, and the physician finds his art serves him greatly, by enabling him to minister medicines, which shall prevent the painful sensations, without interfering with the curative process; for if he do nothing but check the pain, nature will be able to cure the disease, when otherwise she would have failed. I see, however, so much perfection in the human system, that I am always inclined to adopt the expression of the poet, " whatever is, is right," and to think the reason why I cannot see it so, is owing to my short-sightedness, and fear if I should change any thing, I should be hanging the " pumpkin on the oak," only to fall upon my head and fell me to the ground.

347. Painful or unpleasant sensations—quite opposite to pleasant or delightful ones—tend to produce melancholy, to depress the spirits, to lower health, and shorten life; to render the disposition fretful, and make objects repulsive or disagreeable.

It is to be expected, therefore, that the sick will be less amiable than when well; and allowance must be accordingly made. Every thing which will tend to cause disagreeable sensations, must be avoided; and the attention of the mind so occupied with sensations which will not prove hurtful, that painful sensations will not be produced. When children are sick, this is especially important. And sick or well, we should avoid all those causes which produce unpleasant sensations.

SECTION 2.—*Objects producing Sensations.*

348. An object is any thing which is the first acting cause, that produces a sensation.

This object may be external—as when ice produces a sensation of cold; a pin, a sensation of pricking; a rose, a sensation of smell, &c.,—or it may be internal, as when any diseased condition of any part of the body produces, or causes to be produced, any sensation.

349. Different objects tend to produce different sensations.

This truth hardly needs illustration; for the reason why objects are called different, is because they produce different sensations. If one object were precisely like another, and without our knowing it should be put in the place the other occupied, we should believe it was the same. There are twins so closely resembling each other, viz., produce such similar sensations, that people do not distinguish them, except they are near together, viz., produce sensations, at the same time, when if the sensations are similar in all other respects, they are different in this, that the objects appear to, and do, occupy different places. Thus two objects will differ, at least in this, that they cannot occupy the same place at the same time.

350. Different objects produce different sensations of certain kinds, and similar sensations of certain other kinds.

Thus a piece of ice produces a sensation of coldness, and a piece of heated iron a sensation of heat—in which respects they differ; but the ice produces a sensation of weight, and the iron produces a sensation of weight—in which respects they produce similar kinds of sensations. Sugar produces a sensation of sweetness, and honey produces a sensation of sweetness—in which respects they agree; but sugar is a solid and honey a liquid, in which respects they differ, and produce correspondingly different sensations. Hence objects are classed. All those which produce similar sensations of any kind, in respect to that kind of sensation, are classed together, and called by the same name, *e. g.*, all those objects which produce a sensation of sweetness, like sugar, are called sweet: all those which cause a sensation like vinegar, in respect to sourness, are called sour; those producing sensations in respect to coldness, like ice, are called cold. Thus sugar, molasses, honey, are called sweet—and in this respect not classed with vinegar; while vinegar, honey, molasses, water, &c., are classed together in certain respects, and called liquids—while sugar, ice, &c., are classed together in one respect, and called solids. Honey and molasses fall into two classes together—they are sweet and they are liquids: that is, they produce similar sensations of two different kinds. Thus,

351. The more kinds of similar sensations any objects produce, the nearer are they considered to be of the same nature; till at last, when the only difference of sensations is

in respect to the places they occupy, they are considered to be of the same identical nature.

352. The same objects may be said to produce different sensations under different circumstances.

But this is not strictly correct; for if it be said, that boiling water produces a different sensation from water of a low temperature—it is not, properly speaking, the water in either case, but the caloric (commonly called the heat) which produces the sensation. Thus when any different sensation is produced by an object, it would be proper to speak of it as a new object; but for present purposes, it will confuse the mind less to adopt the common expression—and draw the mind to the next very important proposition, viz.

353. *That every object has a tendency to produce, under similar circumstances, a similar effect.*

This must be so, or we should be unable to place any confidence in sensations; they would be of no use to us. But when we feel a certain sensation, we say without hesitation, it is produced by sugar, by a rose, by ice, etc. If it be argued that the same objects do really produce, or cause to be produced, different sensations, it is granted. Indeed, that is what I wish to prove, and at the same time, that this *is not owing to any change in the nature of the objects acting, but in the organs of sensation acted on.* If an article produce a different sensation from what is usual, for instance, if it taste differently, it is easily proved that this is not on account of any change which has taken place in the article, for other persons will say they do not notice any change in the sensation it produces. If wine be tasted after sweet things have been eaten, it will taste flat or insipid. If it be tasted after cheese, its flavor is said to be improved. Now the wine cannot have changed its nature while a person has been eating a piece of cheese, because, to those who have not eaten any its taste is not altered. Sensations caused by an object are oftentimes at first unpleasant, but after frequent repetitions, the sensation is different and pleasant. The same world is around all: to one it is full of beauty—every sight is charming—every sound melodious; to another it is so dull and prosy as to be hardly worth living in—it is fruitful in nothing but faults—every object creates ugly sensations. Why the difference? It cannot be owing to the different action of the same objects upon persons, but to the action of objects upon different persons. The things are the same, acting under similar circumstances—our con-

stitutions must be different. When, therefore, an object is called unpleasant it is not using language correctly. It may produce pleasant sensations in another constitution. By such language we attribute to an inanimate thing, an ill disposition and a versatility of character not belonging to it.

354. It should be inferred, then, that, as beauty is in the eye, the music in the ear mental as well as physical, as the nature of things is inflexible and will not adapt itself to us, and as by the power of the Creator it has been made right, and as we are susceptible of change and our organs of adaptation, if the sensations we experience are agreeable all change should be prevented; but if in a world so perfect, so lovely, gloomy and disagreeable sensations are felt, a change should be wrought in the system.

To do this a person may feel encouraged by his own and others' experience of the facility with which changes may be produced. If it be desirable to know what course to adopt, it may be learned by giving attention to the organs of sensation, and the condition of them, necessary to produce pleasant or unpleasant sensations. By the knowledge thus gained, he will be able to produce a state of proper relation between his organs and the objects of nature, which will result in delightful, or if painful, yet profitable sensations.

SECTION 3.—*The Organs of Sense.*

355. These are those parts of the body in which the nerves of sensation commence, and by means of which objects are caused to act in a proper manner upon the nerves.

The most important part of any organ of sense is, therefore, the commencing point of the nerve.

356. These organs of sense are also sometimes the objects which produce the impression upon the nerve.

The skin is an organ of sense; when it is diseased it, like an object

without any thing acting on it, acts on the nerve. In the same manner other parts of the body produce effects upon the nerves commencing in them.

357. Not only is every part of the body an object producing sensations, but it is also an organ of sense, as I presume there is not any part of the body in which nerves do not commence.

358. It is also evident that within the body, the parts producing effects on the nerves come directly in contact with the nerves, and act upon them without any thing intervening.

As in case of diseases of the skin, the part diseased, which in this case is the object, is directly about and upon the nerves through which an effect is produced on the brain.

359. But in case of those nerves through which external objects cause effects to be produced on the mind, it would not be allowable to have the objects act directly, as the nerves would be injured by exposure. Such nerves have, therefore, been covered.

As in case of the nerves commencing in the skin, they will be found a short distance below the outer surface, as in Fig. 50. Also in case of the nerve of taste, commencing in the mouth, and in case of the nerve of smell, commencing in the nose, the points of the nerves will be found just below the surface.

360. In case of the eye and ear, it is necessary that the objects producing the impression upon the nerve should be acted upon in a peculiar way, that effects or impressions may result. Here, therefore, the nerve is found at the bottom of an apparatus adapted to fulfil its duties perfectly.

361. It is evident, therefore, that there are several kinds of organs of sense. Those parts of the body through which any kind of sensation is produced, and which cannot be produced by or through any other part, are considered to belong to the same class. We have six classes: the ear, the eye, the nose, the mouth, the muscles, and to avoid too much sub-

Fig. 50.

Fig. 50.—Represents one half of the cerebrum, A, and cerebellum, B, and medulla oblongata, C An enlargement called a ganglion is seen at D. 1 is a nerve represented as terminating in *a*, *b*, *c*, *d*, *e*, just below *a* at the surface of *b*, in the little eminences or papillæ there found. *a*, *b*, *c*, *d*, *e*, is an ideal representation of an organ of sense, and whatever acts upon the surface of *a* will affect the commencement of the nerves. 1, 2 represents nerves commencing in any part of the body below the surface. 3 represents a plexus by which it is seen that disease may exist at certain parts and not affect all the fibres passing between any point and the brain. 4 represents the section of certain nerves. If the cut end at 4 be touched, a sensation will be supposed to be produced where the ends of 4 naturally are.

division, all the other parts of the body are grouped together and called organs of common feeling.

Though some distinguish the skin as the organ of touch, and all other organs as organs of common feeling or sensation, others make

other subdivisions still, calling the stomach and throat organs of the sense of nausea ; certain parts through which tickling, etc., are produced, organs of the sense of tickling.

A. *The Organs of the Sense of Common Sensation, or Common Feeling.*

362. 1st. *The Skin*. This includes the lining of the eyes, nose, and mouth, and in a certain sense the lining of the stomach, and the whole or a part of the remaining portion of the digestive canal. It is distinguished as the organ of touch, and may be considered as including all those parts of the body which will produce the sensation of contact when merely acted on by an object neither hot nor cold, nor in any way injurious.

The sensation referred to is that indefinite sensation, not pleasurable or unpleasant, which merely informs of the presence of an object in contact with, or touching us, but gives no other definite idea. It is such as is produced by a tasteless substance in the mouth, or by food as it is being swallowed. It is entirely different from the sensation produced if the food be swallowed "the wrong way," and pass into the wind-pipe ; there is then a tickling, an unpleasant sensation. Some have supposed that the sensation of contact or touch, was produced by the difference in temperature, of the object and the surface touched ; but the saliva in the mouth produces a sensation of touch, and if an object be of the same temperature with the body and brought ever so gently in contact, a sensation will yet be instantly perceived.

363. The skin, as an organ of sense, is of use merely in affording to the nerves a proper commencing place, and in protecting them from exposure.

364. For this purpose a thin layer of skin, and but a thin layer, as in Fig. 50, is overlaid upon the nerves, while the layers below serve as a support to the nerves, and allow of their proper arrangement.

How the nerves commence, is not known. Some think that they commence by loops, while others think they commence by points. There is, doubtless, an arrangement of loops to be seen, but it seems

to me these are not the commencements of the nerves, which I am inclined to think commence by points, and form the loops by uniting with each other in a plexiform manner. I shall therefore speak of the nerves as commencing by points; as there is a particular point of the nerve where it is acted on, where the impression is produced, and where the mind always considers that the impression is made. For instance, if the nerve connecting between any point of the skin and the brain be pricked, at any place between the skin and brain, we are so constituted as to believe the point of the nerve in the skin has been pricked. If a man's arm have been removed, and the nerves which commenced in the hand be pricked at the stump, it will seem to him that the hand is pricked, though the hand has been lost for a long time. If the nerves be acted on by cold, it will seem to him that his hand is cold. Thus also if disease affect any nerve in any part of its course, and cause painful sensations, we are so constituted that the mind believes the disease exists where the nerve commences but on farther examination no disease is found at that place, and the experienced physician knows; as a general thing, that disease exists at some point in the course of the nerves connecting that part with the brain. Thus, if the foot be cold, no matter how warm the central parts of the body are in which the intermediate portion of the nerve is situated, the nerve is so made, that, if healthy, it acts on the brain, or on the mind, only according to the impression produced on its commencing point in the foot, and receives no impression from the warm parts, acting through its sides. This is to me one of the most wonderful phenomena to be observed in the whole economy of the system: but to return to the skin.

365. That the nerves may be properly acted upon, the under layer of the skin is formed into a great number of eminences called papillæ (Fig. 51). They may be seen at the ends of the fingers, in rows, beneath the delicate layer which protects them. In those places they are very near each other, in other places they are more remote. In these papillæ the nerves commence.

366. The more numerous these are, the more acute is the power of producing sensation in any part, and the more perfectly can objects be distinguished.

Any one can try the experiment mentioned, by Weber I think, of

Fig. 51.

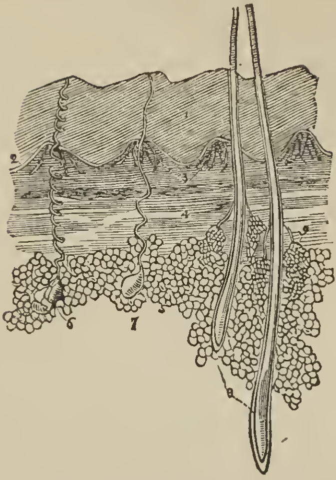


Fig. 51.—1, The cuticle. 2, The rete-mucosun. 3, Two of the papillæ. 4, The deep layer, or dermis—true skin. 5, Fat cells, magnified very much. 6, Perspiratory gland with spiral outlet. 7, Another perspiratory gland with a straight tube as seen in the scalp. 8, The roots of two hairs inclosed in their sacs or follicles. At 9, is seen the short tube of several cryptæ, forming a gland, and which form the oily or sebaceous substance which oozes upon the surface of the skin, to preserve it in a good condition.

immersing the finger, and then the hand, in very warm water. The heat of the water will become apparently more intense, the greater the surface upon which it acts. The heat of the water does not, however, increase, but it seems the sensations become more powerful the greater the number of nerves acted upon at the same time. Thus when the papillæ are thick, the same object will act on a greater number of nerves, than when the number of the papillæ is less. It has been found also that if the points of two needles, at certain distances, touch the skin of one part of the body, *e. g.* the ends of the fingers, they will be distinguished as two things, while, if they touch certain other parts, they will appear as but one thing, and the distance of the points from each other must be increased, that they may appear as two things.

367. The structure of the skin differs in its protective character, in different parts of the body.

Wherever, by use, it is frequently pressed upon, its external layer

becomes tnick, callous, almost horny at times, as upon the soles of the feet, in the palms of the hands, etc.

368. In other respects, as an organ of sense, it does not appear to differ throughout its entire extent. Yet through different parts of it, the same causes produce different effects, which seem, therefore, to be owing not to any difference in the structure of the skin, but a difference in the constitution of the parts, connecting between the skin and mind.

Through one part of the skin, the sensation of tickling can be produced, through another part it cannot. A similar effect is produced upon the skin, in one case, as in the other, but a different effect upon the nerves, because they are differently made. If the odor of the rose be drawn through the nose, it produces a sensation, but if it be drawn through the mouth, when the nose is closed, it does not produce a sensation. The skin, lining these parts, does not seem to materially differ in its structure. The reason for the difference must, therefore, be in the constitution of the nerves, connecting these parts with the mind, as will be hereafter substantiated. It is important to notice this point, viz., the proof that the nerves are differently constituted. I will therefore mention one more illustration. Different parts of the body, are of different temperatures, naturally. The feet are naturally the coolest parts of the body, the head much warmer, but not as warm as the heart, lungs, etc. The hands are warmer than the feet; hence if the hand touch the foot when both, in themselves considered, are perfectly comfortable, the foot will feel cool to the hand, and the hand feel warm to the foot; because the natural heat of the hand, acting upon the nerves of the foot, is too much for them, and vice versa. The comparative warmth or coldness natural to any part, depends on its distance from the heart and the quantity of blood it receives, as will hereafter be proved. The nerves therefore commencing in any part, must be acted on by a degree of temperature, a shade different from that acting on the nerves of any other part, and yet they all produce one sensation—a sensation of comfort. Is it not astonishing that the temperature acting on the nerves of the foot, should produce the same sensation of comfort as the different temperature acting on the nerves of the hand? And if the temperature of the foot rises to the temperature of the hand, and which through the nerves of the hand produces a feeling of comfort, it should, through the nerves of the foot, produce an uncomfortable sensation, of too much heat. There-

fore the nerves of the two parts must be differently constituted ; and the millions upon millions of nerves connecting the various points of the surface of the body with the mind, must be constituted with almost as much variety as there are nerves, and in such manner that each nerve will be acted upon so as to produce an agreeable sensation, by the natural temperature of the part in which it commences, and produce a disagreeable sensation when the slightest change in this natural temperature takes place. It is a wonderful thing that we are made as we are, and almost as wonderful that we know so little how we are made. When the poet sung, " It is a harp of a *thousand* strings," he had but a feeble conception of his subject. Indeed, the eloquence of man must be dumb, when the perfection of the Creator's works is before us.

369. The uses of the skin, as an organ of sense, may be considered under three heads. In the first place:

370. It may be considered as producing negative sensations; that is, those which cause neither pleasure nor pain.

It produces such sensations when any thing comes in contact with it, if the thing be neither profitable nor harmful. There is no reason why, in such a case, pleasure or pain should be produced; it will do us no harm if the object touch us, it will do us no particular good. The instant it becomes harmful, the skin produces an additional sensation of pain ; and when necessary for our welfare, it produces a sensation of pleasure. This negative sensation, is called the sensation of touch. Some suppose sensations of touch inform the mind of the solidity of an object by the depth to which the object acts; that is to say, if the finger be pressed upon any thing, which is soft or yielding, it will produce an effect only on the nerves, commencing near the surface—if the object be more solid, it will act on nerves commencing deeper. Some also think, that the form and size of many things are determined by the number and position of the nerves through which the sensation of touch is produced ; that is, if an object one inch long be touched, it will affect only half as many nerves as if it be two inches long. Some think the smoothness of an article is determined by similar sensations; as, if an article be rough, it touches only a few nerves, the commencements of which are not near each other—while, if the article be smooth, each nerve is acted on. But it would seem, these things are determined partly, if not wholly, by muscular sensations, as hereafter shown.

371. Second. It may be considered as producing positive sensations of pleasure or pain.

Its duty is, to produce such sensations, especially when acted upon by proper or improper temperatures. Preserving a certain temperature is so important to health, that it is rewarded with the most pleasurable sensations; while the slightest deviation is noticed by corresponding unpleasant sensations. And as the whole duty of guarding the system, in this respect, depends on this organ of sense, it might pre-eminently be called, the organ of the sense of temperatures. How much it adds to the enjoyments of life, every one has appreciated when walking in the field or resting in the shade, quite satisfied with the delicious sensations of a summer's day. Still more was it our friend, if perspiring and exhausted, we thoughtlessly threw ourselves down where the temperature of the body was reduced too rapidly. The cold chill that ran through the frame, aroused us to safety. All injuries from which the skin suffers, will excite it to cause unpleasant sensations. It is thus our never sleeping guard.

372. Third. It may be considered as the organ of the sense of tickling, and many other such sensations which are worthy of merely a notice.

The particular characteristics of the skin, as an organ of sense in the mouth and nose, will be mentioned hereafter.

373. To fit the skin for fulfilling its duties as an organ of sense; in the first place, it will be necessary that the external protecting layer, called the cuticle, scarf-skin, epidermis, &c., be flexible, delicate, and as thin as the position it occupies will permit.

374. To preserve these good qualities, it is constantly lubricated with an oily fluid, formed in little pouches or bags, called cryptæ or follicles (Fig. 51), and poured out upon the surface through their open mouths.

As this fluid is of an oily nature it must be constantly removed from the skin, otherwise a collection of it will take place, which becoming gummy, will prevent the existence of that delicacy which it is intended to preserve. That it should be oily, is evident enough, as it was necessary it should protect the skin from the action of water and other things;

which are decidedly injurious, as is seen when the oil has been removed from the skin, not only, but drawn out from it by the continued application of hot water—especially if assisted by soap, *e. g.* the hands of the washerwoman. The skin is not then delicate and well adapted to act as the organ of touch. A proper application of water, perhaps, assisted by soap, is to be recommended; not such that the oil shall be exhausted from the skin, but merely removed from its surface. To assist this, the skin may be vigorously rubbed with a towel, more or less harsh, as the case may require, and as may "feel comfortable."

375. The fluid being formed from the blood, a plentiful supply of this is necessary.

This is obtained by general exercise, for that action of the muscles which urges the blood along through themselves, assists in circulating it through the skin; by briskly rubbing the skin, for the efficacy of this may at any time be seen, the skin glowing with the life-giving blood that is brought into it by rubbing any part; and by proper clothing, for without this, the blood cannot be long retained in the skin.

376. To fit the skin for fulfilling its duties; in the second place, it will be necessary to preserve a free circulation of blood, through the deep layers of the skin; for on the reception of blood in ample quantities, depends the life and energy of the nerves.

If a person be exposed to the cold, which contracts the bloodvessels and shuts out the blood, the part affected becomes numb. On the other hand, if the bloodvessels are overloaded with blood, and its circulation thus checked, sensations are equally indistinct and vague. The same means which will supply blood for the formation of the oily fluid, will supply it for the good of the nerves at the same time. This illustrates what will often be noticed, that what is for the good of a part, in one respect, is good for it in all, and never injurious.

377. 2d. We may now consider the remaining organs of common feeling. All parts of the body are thus grouped together, not because they produce similar sensations, particularly speaking, but because the sensations they produce are for the same general purpose, viz., to inform the mind of the good or bad condition of any part of the body,—of a good

condition, by producing pleasurable sensations—of a bad condition, by painful or unpleasant sensations; and because the arrangement for acting on the nerves is similar in all these parts, viz., the parts or organs act directly on the nerves, which commence in them.

If each part which produces peculiar sensations were considered as an organ of sense, this group would be very much subdivided. The sensations caused by the windpipe, when any thing falls into it, are dissimilar to any others, and the lining of the windpipe might be distinguished as an organ of sense. A decayed tooth produces a peculiar pain, and that might be called an organ of sense; and so every other part, which constantly produces peculiar sensations, might be looked upon as an organ of sensation; but this subdivision would be useless. By nature or by experience we learn the meaning of the various sensations; that is, where and how they are caused; and are thus able to give attention to the cause of the evil, and what is still more important, to the prevention of its re-occurrence.

B. *The Muscular Sense.*

378. Before the time of Sir Charles Bell, the muscles were not considered as organs of a particular sense, but were included among the organs of common feeling. He called attention to the importance of distinguishing the muscles as organs of a peculiar sense, and was the means of exalting them to their proper station.

379. The nerves which connect between the muscles and the brain are acted on immediately by the contracting muscle, different sensations being produced by different degrees of contraction.

Thus, if the muscle contract or shorten one inch, one sensation will be produced; if the muscle contract two inches, or more, or less, a different sensation will be produced. Hence

380. The mind knows the degree of contraction of the muscle, by the sensation produced.

And as the contraction of the muscle produces correspondent motion of some part of the body,

381. The mind knows the amount of motion produced, and also the kind, by the sensations produced.

Thus the mind is able to guide the motions of all parts of the body; *e. g.*, if a person wish to raise the hand in a straight line, the mind, from previous experience, knows the sensations the muscles should cause, when contracting in such a manner as to produce the desired motion; as soon, therefore, as any other sensation is felt, the mind checks the action of the muscle or muscles producing the wrong sensation, and causes the proper contraction to take place, thus regulating the motion.

382. Another kind of sensation is at the same time produced, viz., a pleasurable sensation, of a character peculiar to the proper action of the muscles.

The reason for this is quite clear: the action of the muscles is so essential to man, that it is important they be always kept in a healthy condition. This cannot be without exercise. If it be not *necessary* to use them to-day, it may be to-morrow, or the next day, or the next. It is essential that they be exercised to-day, and every day. A pleasurable sensation has been therefore wisely caused to attend the exercise of the muscles, as a reward, and also

383. Another sensation of an unpleasant character is produced, when the muscle is not exercised, to punish us for not doing our duty.

384. Another sensation is produced, when the muscle has been over-exercised. This is to induce us to allow it repose, that it may recover that strength, healthy condition, and perfection, it has in a measure lost by action.

Some suppose that rest, after muscular action, is necessary, rather for allowing the nervous system, than the muscular, to regain vigor. But as the sensation of weariness or fatigue is felt only in the muscles exercised, the supposition seems to be gratuitous. When the nervous system is exhausted, the person is apt to express himself—"I feel tired all over."

385. Another sensation is felt when repose is given to the muscle. This is of a pleasurable character, and is to reward a person for care, and to induce it on other similar occasions.

386. Still another sensation is felt, when the muscle is cut, bruised, &c., or diseased.

This sensation seems to be of the same character as those produced by the organs of common feeling or sensation; and in this respect the muscles might be included in the same category with them.

387. The sensations produced by the action of the muscles, enable us to determine the hardness of an object, its form, its size, and to a degree, if not wholly, its smoothness, &c.

For if the muscle be contracted to a given degree, and motion is yet resisted, the object would be considered correspondingly solid; *e. g.*, if the finger be placed upon dough, and the muscles of the arm which move the finger be contracted to a certain degree, motion of the finger is produced; while, if the finger be placed upon the table, no motion of the finger takes place, with a similar contraction of the muscles. The table is then called harder than the dough. The form of an object is determined by the contraction of the muscles as the hand is laid upon its surface. For instance, if the muscles contract so as to draw the fingers perpendicular with the palm of the hand, the object is considered to have a square edge. If the muscles contract, as when the fingers grasp a ball, the object is considered spherical. Of course, in this case, the sensations produced by touch assist and are essential; for the form of an object is determined by the contractions of the muscles necessary to cause its surface to be touched by the body—more commonly by the hand or fingers. In the same way, the size is determined. For as a greater or less contraction of the muscles of the arm is necessary, to sweep the hand over the object, so is the object regarded as larger or smaller; and as the muscles meet with more or less opposition, so is the object regarded as smooth or rough.

C. *The Sense of Taste.*

388. The tongue and back part of the sides of the mouth are the organs of the sense of taste.

The skin lining the entire mouth is at the same time the organ of the sense of touch and common feeling. A bit of sugar placed any where in the mouth produces a sensation of touch, but only in certain parts, the sensation of taste. The sensation of taste is not caused through the same nerves, therefore, as the sensation of touch; this is

also proved by the effects of disease, which sometimes takes away the power of tasting without affecting the power of touch, and vice versa. That is, by disease a person is unable to taste sugar placed upon the tongue, though the sugar produces the sensation of touch the same as ever, or in other cases he tastes the sugar when it produces no sensation of touch.

389. The organs of taste may be considered as double, the central line on the surface accurately dividing the tongue into two tongues, so far as tasting is concerned.

This is proved by dissection, and by disease, which sometimes unfits the nerves of one side for performing their duty.

390. The nerves of taste commence in the lining of the mouth in the same manner as the nerves of touch. The papillæ in which they commence are much more numerous at the tip of the tongue than elsewhere, hence that is the part which produces the most lively sensations.

It is proper it should be so, for that part can be thrust from the mouth, and with it articles can be tasted before they are allowed to act on so great a number of nerves, as when taken into the mouth.

391. By some it is thought that all the nerves of taste are not of the same quality; that is to say, that the same things produce one kind of sensation through the nerves connecting between the tip of the tongue and the mind, and another kind of sensation through the nerves connecting between the sides of the mouth and the mind.

They illustrate the idea by what every one may notice, viz., that some articles taste differently after they have been in the mouth a little time, which these persons suppose to be owing to the opportunity they have had of reaching the nerves farther back in the mouth. Others explain this phenomenon, by supposing that after some substances have acted for a little while upon the nerve of taste, they alter the nature of the nerve in such a manner that it produces new kinds of sensations. One thing is certain,

392. The nature of the nerves of taste is very easily changed, both transiently and permanently.

In proof of this, the common fact need only be mentioned, that food

which it is very disagreeable for us to taste at first, becomes delicious in a short time, not more because we become accustomed to the taste than because the taste is changed. The taste of an article depends much, also, upon what articles are combined with it, and what articles have been eaten previously. A variety of articles by themselves, produce such sensations we cannot relish them at all; when mixed in proper proportions they produce exceedingly agreeable sensations. *In this lies the great secret of cooking*, viz., to combine articles in such a manner as to cause them to relish. *Another secret consists in this*, viz., to place articles before a person in such order, that eating one shall increase the relish for another, and improve the sensations it produces. By breaking both these rules, some housekeepers with the greatest abundance, never have any thing fit to eat, or one thing, if good, spoils the taste of another good thing which follows it; while by giving attention to these principles and learning how the taste is generally acted upon, or particularly acted upon in particular cases, a housekeeper with very small means will always have a delicious table. I have known persons to be so unskilful as to put on the table, to be eaten with meats, richly preserved fruits, perhaps thinking they must be nice, because expensive, while with meats, being more or less of a fatty nature, something acid is agreeable; plain apple or cranberry sauce would have improved the meat, and the meat the sauce; thus the old proverb is true, "one person will prepare a better dinner with a shilling than another with a pound." A Frenchman will make a delicious soup with what ordinary cooks will throw away. In this, as in every thing else, it is not the outlay of money, but mental application, which will gain the desirable end.

393. The use of this sense is to give pleasure while eating, that we may be induced to chew the food thoroughly, and allow it to be mixed with a good supply of saliva; two very important things in the digestive process. It also facilitates digestion, by causing a *free flow* of saliva. "The mouth waters," is a frequent description of the effect of food before it is tasted. Much more powerful in the same way is the action of the food when taken into the mouth. A somewhat similar influence causes a free flow of digestive fluids into the stomach, as shown hereafter.

As previously shown, it is very important that we cultivate a relish

for wholesome food, and then that we eat it only when it is highly relished, and that we enjoy it to the full, by the allowance of proper time, etc.

394. That substances may produce an effect on the nerves of this sense, it is necessary that they be dissolved. For this purpose the constant flow of the saliva is well adapted.

395. When the mouth becomes dry, as well as when the organs of sensation are diseased, the sensation of taste will be wanting or very much changed.

This sense in animals serves them instinctively to distinguish between wholesome and unwholesome food. Some have thought that it would be the same with man in the uncultivated state. One thing is certain. the taste of animals, as well as of man, is easily changed, and as the taste of animals can be preserved, so can that of man without change. If a child be always fed upon milk, it will, when young, desire nothing else, for why should it desire to taste something it never tasted? If we, when mature, find any new thing, we have so little desire to taste it, that we use great caution, and at first taste but a bit; indeed we have no *desire* to taste it. The child who has never had a bit of sugar or sweetmeats placed in its mouth will never *desire* it, and, therefore, never cry or fret because it does not receive it. *A child should never, therefore, receive the least thing except its wholesome food, until it is old enough to understand why it should have but little of certain things, and only at certain times.* Thus will the mother save the disposition of the child from a great source of injury, and save herself much trouble, while certainly, the health of the child will be much the better. I have known, as every one has, a mother to give a child a bit of sweetmeats which has been the means of a hundred crying fits; for every time the child saw the like, it would wish to eat, and the mother would not dare to give what the child wished.

D. *The Sense of Smell.*

396. To understand this sense we must, in the first place, give attention to the objects which act upon its organs. The rose may be at a distance from us, and yet we perceive its odor. The whole air is sometimes filled with the fragrance of the fresh-blown clover field. The rose itself does not, of course, affect us. The usual opinion is, that exceedingly minute particles of the rose and all odorous bodies, are continually

coming off from them, and that these act upon the nerves. Of course, if this theory be correct, the greater the number of particles acting on the nerves at the same time, the more powerful would be the sensation; and it is usually found that the most odorous articles are very volatile (flying). But some articles have been said to render a large space fragrant with their qualities for years; and yet without losing weight appreciably. We can hardly conceive of particles so minute as this would require—and a variety of arguments have induced me to suppose the ordinary philosophy was not quite correct; but it explains most phenomena well enough, and I shall adopt it. Suppose the air then to contain particles of a rose or any thing else, it will next be necessary to have the air pass over the nerves; and the greater the number of nerves it passes over, the greater the probability that many of the nerves will be affected by the particles, few or many, which the air contains—and the greater the quantity of air passing over the nerves, the greater the probability that many nerves will be acted upon, and an intense effect be produced therefrom.

397. The nose is exceedingly well adapted to be the organ of the sense of smell.

The lining of the nose is also the organ of the sense of touch and common feeling; as substances may produce the sensation of touch or pain, without causing that of smell. By disease, also, a person may be devoid of either the sense of smell or touch, without the other being lost. There must, therefore, be two kinds of nerves connecting between the nose and mind—which is found to be the case.

398. It is composed above of a bony framework, which is lengthened down by cartilage.

The yielding nature of this, prevents the prominence of the nose from being objectionable on account of its liability to accident; while the elasticity of the cartilage, preserves a free passage to the air. The yielding nature of the cartilaginous portion also allows the passage to be closed, if the air be unpleasant, or narrowed when it is desirable to inhale the air with increased force.

399. The nose is divided above by bone, which is also lengthened down by cartilage.

This increases the extent of surface in either half of the nose, and in fact divides, for all the purposes of smell, the nose into two noses; for

the sense of smell may be lost in respect to one nostril, and may remain in respect to the other. And the nature of the nerves connecting between the nostrils are sometimes different; so that, as some persons have one sensation when a substance acts on one side of the tongue, and a different sensation when the same substance is moved on the other side of the tongue—so some persons have one sensation produced when odor acts through one side of the nose, and another sensation when the same particles act through the other side.

400. Several bones, called turbinated (coiled) or spiral (Fig. 52), are attached by one edge to the outer and upper side of the inside of the nose. The other edge hangs down into the nasal passage, and is somewhat coiled; though not as much in men as in many animals.

Fig. 52.

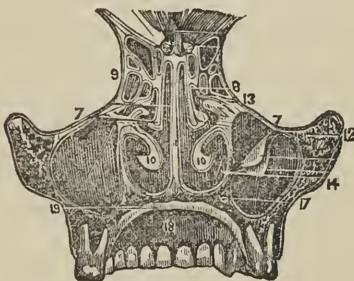


Fig. 52.—Is a perpendicular section of the face-bones, through the nose and across its passages. The figures 7, 7, are placed in the sockets of the eyes; 12, is the cheek-bone, within which is seen the antrum with a small bit of its lining raised up. In the antrum of the other side, a bristle is represented, thrust up through an opening into the nose, the cavities of which are divided by the vomer 11, and partially divided by the lower spongy bones 10, 10, and middle spongy, to which the lines from 7 lead; 18, the roof of the mouth.

By this arrangement, two objects are gained. In the first place, the lining of the nostrils presents much more surface to the action of the air, and in the next place, the nasal passage being narrowed, there is much more probability that the odorous particles, which the passing air contains, will act upon one part or another.

401. The nerves of smell commence in papillæ, found beneath the surface of the delicate lining of the nasal passages.

Thus, as the air, by the action of the breathing apparatus, is swept through the passages of the nose, the odorous particles of one substance produce one effect, those of another substance produce another effect. The question might be asked, if a particle of substance, after it had acted on one nerve, could be carried on to act on another? This is not known, probably it could not.

402. To facilitate the action of odorous particles, it is necessary that the lining of the nose should be kept in a proper condition by a substance, serving the same purpose as the oily substance poured out constantly on the skin.

It is formed in a similar manner, and differs in its nature, only to be better adapted to the wants of the part to which it is supplied. It is very similar to the substance which is supplied to the lining of the mouth, and readily seen, looking like the white of egg, if a spoon or knife be scraped gently down upon the surface of the tongue.

403. The lining of the nose is also kept in a proper condition by the fluid which has already served a similar purpose in the eyes.

When therefore either of these fluids is wanting, the power of the sense of smell is correspondingly deficient. So on the other hand, when the supply is too abundant the sense of smell is injured. Both of these things are frequently illustrated by the effect of colds.

404. In man, this sense seems to be chiefly useful by increasing the pleasures of existence. It prepares and increases the appetite for the preparing food.

This sense is so seldom wanting at birth, (I never knew but one case,) that it may be of much more use than at first appears. In case of animals, it appears of great use in distinguishing their food, and wonderful things are told by travellers and naturalists of the acuteness of smell of certain birds, etc. But I do not place confidence in them, as there is no reason it should be so. The acuteness of smell in case of the hound is owing, in great part, to the great extent of lining surface of his nostrils, by which a large number of nerves can be presented to the action of air which he snuffs.

405. The sense of smell seems to affect the sense of taste, or rather certain sensations which we call sensations of taste,

seem to be made up of effects produced through the organs of smell and through the organs of taste.

For if the nostrils be closed, certain articles produce little if any taste. An idea to be taken advantage of, when a person must swallow unpleasant things. The near alliance of the nerves of taste and smell is also seen by what every one has noticed, that one thing tastes as another one smells, or vice versa. That is, the sensation which one thing produces through the nerves of taste, is similar to the effect another thing produces through the nerves of smell.

406. There are various cavities connected by small openings or tubes with the nostrils. 1st. There is one within each cheek bone, called an antrum, with a tube opening into the side of the nostril. There is one within the ridge of bone felt beneath each eyebrow, called a frontal sinus, with a tube opening into the upper part of the nose. The inner end of this sinus sometimes almost meets that of the opposite, its other end being found within the outer end of the eyebrow. Sometimes they are a little distance from each other at their inner extremities, and short or long as the case may be. Sometimes they are broad, either up and down or from forward back, being large or small as the case may be. Sometimes their size is indicated by an external prominence, sometimes not. There are other small cells or cavities in the bones forming the roof of the nose; their tubes open into the top of the nose.

407. The skin or membrane lining these cavities is continuous with that lining the nose. It forms and pours upon its surface a similar substance, though not in so large quantity. The tubes heretofore mentioned are the outlet of this fluid. Colds sometimes increase, sometimes diminish the quantity of fluid formed, and sometimes at the same time cause a closure of the outlet. A collection then takes place in the cavity. Severe consequences usually follow in a short time. Similar disease of the membrane, though not the result of colds, will produce like results.

E. *Sense of Sight.*

408. The eye is very admirable, both on account of its beautiful structure, and the perfect manner in which it fulfils its duties. But it is exceedingly difficult to render its mode of action perfectly clear. With the aid of lithographs, however, if the reader will assist with his imagination, and give his undivided attention, the task may perhaps be accomplished. He must, however, pardon the author, if, in the earnest attempt to render the subject clear to every understanding, the description should appear, by the homeliness or simplicity of expression or illustration, to fall below the dignity of a book treating upon optics. If he be in the habit of reading upon these subjects, he will confer a favor on the author, and perhaps on himself, by reading as if a beginner, following step by step, without anticipation, as explanations may then appear proper, which otherwise would seem unnecessary; and the language used is intentionally different from what is usual; some very familiar expressions will carefully be avoided, nor should the reader allow his mind to suggest them. The eye is neither a telescope nor a microscope, but an apparatus with which to see. How do we see? is the question to be answered. And if, in following the author, the reader arrive at the same conclusions he has often before, as it is expected he will, it will perhaps be by a way somewhat new, except to physiologists, and free from many sources of confusion to which descriptions of this sense are usually liable.

409. If the eye be directed toward yonder tree, it apparently produces a sensation; that is, it is seen. If the eye be closed, the sensation ceases.

410. The eye is, therefore, the organ of sense through which the sensation is produced. It is the organ of the sense of sight.

It will by this time be easily remembered, that when an effect is produced on the nerve commencing in the organ of sense, that effect is called an impression. This effect or impression acts through the nerve and brain upon the mind, causing a sensation. It will be convenient in this division of the section, to make free use of the word impression.

411. If the tree be removed, the sensation will cease.

412. The tree must therefore be one of the causes of the impression made upon the eye.

413. But the tree is at such a distance that it cannot itself act on the eye. Yet something must act on the eye, and something must be caused to act on the eye by the tree. That something is called light.

414. Light, therefore, is that something which objects more or less distant cause to act on the eye and produce impressions.

Some think that light is composed of very small particles, which objects cause to act on the eye. Others think that there is a substance very much more subtle than air, existing throughout the universe. This fluid, as it is sometimes called, or ether, as it is also called, is supposed to be thrown into waves by the action of objects, and these waves caused to act on the eye. It will make no difference at present, in any practical respect, which theory is adopted; but as the language used in connection with the first mentioned is more easily understood, light will be here considered as composed of exceedingly minute particles. *These always move in straight lines* till they meet some object which turns their course, when they again move in straight lines. A series of these particles of light following each other, is called a ray or beam of light. Whether in a ray of light the particles are very near each other, or at considerable distance, is not known; nor is it known whether they are nearer in some cases than in others. The quickness or velocity with which they move is almost incredible.

415. But in a few hours the sun will set, and leave the world in darkness. The tree will remain, and the eye may remain, but the tree will not produce any sensation. The action of the tree, therefore, depends upon the sun. But the sun does not touch the tree. The sun must, therefore, cause something to act upon the tree, causing the tree to cause the light to act upon the eye.

416. How this is, is made known by examining the nature of light. The particles of light, when striking against certain objects, bound off like india-rubber balls. If a handful of these be thrown against the wall, some would bound off or be reflected (turned back) in an upward direction, some downward, some to one side, others to the other side, and thus be scattered over the entire room. Thus is it with light.

417. The idea, therefore, is this, viz., that the sun acts upon the tree by means of light, the particles of which pass from the sun to the tree upon which they strike; it then reflects or bends them in various directions, and some of the particles being bent or reflected so as to

come in a straight line to the eye of the observer, an effect or impression is produced. Hence

418. Various objects produce an effect through the eye by reflecting light upon, or rather into it.

419. But yonder house by the side of the tree also produces an effect or impression upon the eye. The light of the sun must also strike upon that and be reflected to the eye. But the sensation produced is different from that produced by the light coming from the tree. The impression must of course be different, and the light producing the impression must be different, therefore the light coming from the tree must be different from that coming from the house. But the light coming from the sun to the tree is precisely similar to that coming from the sun to the house. These objects must, therefore, do something more than merely bend the light; they must change it so that it will cause different impressions after it has left them, for the light is similar before it comes to them, but different afterwards. How this is will be understood by noticing, in the first place, that

420. The light coming from the sun is composed of three kinds of light.

421. When all three kinds act on a single nerve at the same time, they produce the same sensation as when light from the sun acts on it. It is called the sensation of white light, or whiteness. If one kind act by itself, it produces the sensation of red. If a second kind act by itself, it produces the sensation of yellow. If the third kind act by itself, it produces the sensation of blue. If the first and second kinds, in proper proportions, act at the same time upon the same nerve, they produce a sensation of orange. If the first and third kinds in proper proportions act, they produce a sensation of purple. If the second and third kinds in proper proportions act on the same nerve, they produce the sensation of green. Thus every variety of sensation of color is caused by the action of one or several kinds of light at the same instant on the same nerve. When the nerves are not acted on by light of any kind, they cause a sensation of blackness, as when a person goes into a perfectly dark room. *Sensations produced by the action of any kind of light singly, are called simple sensations. Sensations produced by the action of more than one kind of light, are called compound sensations.* If it be asked, How are all these things known? The answer is, by the use of proper apparatus the light of the sun can be separated into three

kinds, either of which, or any combination of them, can be made to act on a nerve of the eye at the same instant. We are now prepared to notice, in the second place, that

422. Some objects absorb (drink up) all the light that falls upon them, while others reflect all that falls upon them; while other objects again, absorb one kind, or two kinds, or part of one kind, or two kinds, as the case may be, and reflect the rest.

423. The reason is now instantly seen why objects produce different impressions. Yonder house absorbs the yellow and blue light and reflects the red, and hence produces a sensation of red. The tin upon the roof does not absorb any, but reflects all kinds just as they come from the sun, and the same effect is, of course, produced as if the light came from the sun directly to the eye; a sensation of dazzling whiteness. The posts in the yard absorb all the light and do not reflect any, nor produce any effect on the eye, and the want of this effect causes the sensation of black, and we say we see the posts to be black. The leaves of the tree absorb the red light and reflect the yellow and blue, which together, acting upon the eye, cause the sensation of green. But when the frosts of autumn shall change the nature of the leaves, some of them will absorb the red and the blue, reflecting only the yellow, and producing, therefore, the sensation of yellow, while others will absorb the blue and yellow, and reflect only the red. Thus by the change in the nature of the leaves, and their power of absorption and reflection of light, which falls upon them, is produced all the gaudy beauty of our autumnal forests. For when night comes on and there is no light to be reflected, all things alike want the power of producing sensations, and as the eye strives to pierce the darkness of the forest, it causes only the sensation of blackness.

424. Some objects *produce* light, which passing directly to the eye, causes sensations. Thus objects are of two kinds. 1st. Those which produce sensations by their own light, and 2d. Those which produce sensations by reflecting light produced by other objects.

The sun, candle, the fire, and the like, are examples of objects causing sensations by their own light. The kind of sensation they will produce, will depend on the kind of light they produce. The sun, "the great

fountain of light," produces all three kinds of light at the same time. Some other light-giving objects, however, produce but one kind of light; most objects, however, produce several kinds. It is now desirable to state distinctly an important proposition.

425. When different kinds of light act at the same time on the end of the same nerve, a compound sensation must be produced. *In order, therefore, to have the light coming from different objects produce distinct sensations, it must act on the commencing points of different nerves*, and the more perfectly this is accomplished the more distinct will be the resulting sensations; this is the great office of the eye.

Yonder now is the house, which produces the sensation of red, and the leaves of the tree, which produce the sensation of green, because the red light is reflected by the house, and the yellow and blue by the leaves. If the light from these two objects acted on the end of the same nerve, at the same time, the sensation would be that of white, because all three kinds of light would be acting at the same time on the same nerve. But the red light from the house does enter the eye at the same time with the yellow and blue light coming from the leaf, and yet a distinct effect is produced. Therefore there must be more than one nerve in the eye, and the eye must be so made as to cause the light coming from the house and entering it, to act on one nerve, and the light entering it from the leaf to act on another nerve. It must be the same in respect to the light coming from any and every object we see; thus,

426. The number of objects which we can distinguish being very great, the number of nerves commencing in the eye must correspond (Fig. 53).

That the reader may comprehend how the different nerves are acted upon by the light coming from different objects, at the same time, and in such manner that each nerve acted on shall be affected only by the light coming from its own object; let him try the experiment of placing several candles near each other. Then having made a pin-hole in a sheet of paper or pasteboard, hold it in such a manner within a few inches of the candles, that the light from all of them will shine through the pin-hole; let then some object be held a little distance from the pin-hole, upon the side of the paper opposite the candles. He will thus see that light moves in straight lines, for the light goes directly on from the pin-

Fig. 53.

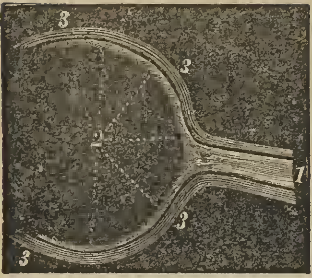


Fig.53.—3, Represents the outer coats of the back part of the eye. 1, The optic nerve composed of millions of fibres. 2. An ideal respresentation of the commencement of the fibres. Between the nerves and outer coats is seen the pigmentum nigrum.

hole in the same direction it had while coming from the candle to the pin-hole, and he will quickly see which spot the light from any candle produces, by blowing out a candle, for its spot will instantly vanish, and reappear if the candle be lighted. He will also see that the light from one candle crosses that from another at the pin-hole, without any interference. How or why this is, cannot be told, but it is an evident fact.

If now he look at lithograph Plate 5, Fig. 1, he will notice a representation of the eye in outline, as a box of a spherical form, with an opening in front; just back of this is a partition with a hole in it corresponding to the pin-hole in the pasteboard, and in the back part is seen the commencing extremities of a great number of nerves, each one of which extends back to the brain. In front of the eye are placed three candles, producing red, yellow, and blue light. When the light coming from each is mingled, as it is in passing through the hole in the partition, *a*, it would cause the sensation of white light, if a nerve were there to be acted on; but when the red light has gone through the hole, it, like the others, pursues its straight course, and therefore acts on its own nerves at the same time the blue and yellow light act on their nerves.

427. The more light there is acting on any nerve at the same time, the more intense will be the sensation produced.

This is almost self-evident. When we go into a nearly dark room, there is so little light acting on the nerves, that objects can hardly be discerned; while if we go out doors, of a bright winter's day, the light

reflected from the snow, painfully dazzles. Under some circumstances, therefore, it will be desirable to have as much light as possible enter the eye; while in other cases, it would be desirable to shut out the light. It is evident such an end could be gained by enlarging or lessening the hole in the partition *a*. For if it should be enlarged, more light would be admitted; while if it were lessened, so much light as now could not reach the nerve.

428. If the reader take the pains to hold a candle near to the eye, and remove it and re-bring it towards the eye of another person, he will perceive an enlargement and lessening of the hole, called the pupil, seen in the colored part of the eye, called the iris, which corresponds to the partition (Lith. Pl. 5, Fig. 1) *a*.

It would now seem that all the requirements for seeing are obtained; but the most difficult part of the matter yet remains. It is seen that the light from three candles (Lith. Pl. 5, Fig. 1) acts upon a large portion of the nerves in the eye. But with the eye we can distinguish a thousand candles, which could not of course be, if no other arrangement existed than that already described. If the hole in the partition *a* be made very small, then only a little light from each object would pass through, and act on a correspondingly small space, in the eye; and there would then be room for the action of light from a great many different objects. It has, however, been seen, that in a dimly lighted room, where only a very small amount of light acted on the nerves, but a slight effect was produced. With so small an amount of light as would pass through a pin-hole, acting on the nerve, the effect would not be so powerful as necessary; more light must, therefore, be allowed. But when the opening is large, it is seen in Lith. Pl. 5, Fig. 1, that the light acts over many nerves; so that no more light acts on *one* nerve, than if the hole in partition *a* were smaller. Though in this case the sensation would be stronger, it would yet be feeble. If, however, any thing can be done by which the light passing through the hole in the partition, which I will now call the pupil, can be concentrated (brought to a centre or point)—that is to say, the red light be brought to a point by itself, and the blue and yellow light brought to points each by itself—the desired end will be gained; for then all the light from one object passing through the pupil will be made to act on a single nerve—and there can be as many different sensations as there are nerves, if there are only as many objects to cast their light through the pupil. To understand how this is accomplished, we must notice a third effect, which is produced upon light by some objects.

429. Some objects transmit (send through) the light falling upon them—as window-glass transmits the light of the sun. Such objects are called transparent.

Some objects transmit one kind, and reflect the rest; or transmit a part of all, and reflect a part of all. There are very few, if any objects, which transmit all the light falling upon them.

430. If a ray of light fall perpendicularly upon the surface of a transparent object, as C, D (Fig. 54) falling on the surface S, I, the light will not be bent out of its course.

Fig. 54.

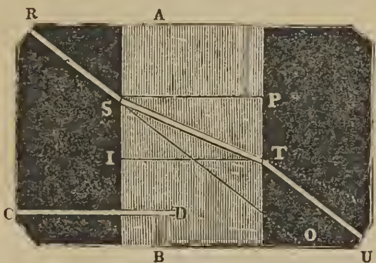


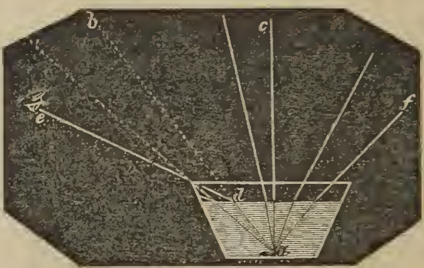
Fig. 54.—R, S, T, U, represents a ray of light passing obliquely from the air S, I, into the glass A, B—and from that into the air P, T; R, O, would be the direct line S, P; I, T, perpendiculars; C, D, a ray of light entering the glass perpendicularly, and of course not bent.

431. If a ray of light fall upon the surface of a transparent object in an oblique or slanting manner, the light will be bent just at the surface of the object it is entering, as shown by R, S, T, U, Fig. 54.

An experiment illustrating this can be tried by putting a quarter of a dollar in an empty bowl. Then place the bowl in such a position that the light coming from the money over the edge of the bowl will not enter the eye, but pass a little above it as in (Fig. 55) the line of light a, b. If water be poured into the bowl, the light which passes from the money perpendicularly into the air at *c*, *a*, will not be bent, but pass the same as before the water is poured into the bowl; but all the light passing from the money through the water and entering the air in a slanting direction, will be bent, and the light which passes in the line from the

money to the edge of the bowl, when there was no water in the bowl, passes in the same line as far as the surface of the water, but as soon as it enters the air it is bent and strikes against the bowl, while the light which left the money in the line *a, b,* before the water was poured into the bowl, follows the same course as far as the surface of the water, when it is bent so as to take the line *a, d, e,* which passes into the eye and produces an impression. This is the reason why pouring water into the bowl enables a person to see the money, though the bowl and eye are not moved.

Fig. 55.



432. The more slanting or obliquely the light enters from one object into another, the more is it bent.

This is represented by the lines in Fig. 55, between a, b, and a, f.

433. It is also seen that the light passing from the water into the air, in Fig. 55, bends *from* the perpendicular *c, a,* to the surface of the air. This is true of the light passing out of the water on each side of the perpendicular. Now the air into which the light passes, is not as dense as the water out of which the light passes into the air. Therefore as this is always the case,

434. It is a rule or principle that light passing from a denser or more solid object into a less dense or less solid object, is bent *from the perpendicular to* the surface it is entering.

435. In Fig. 56, light is represented as passing from air into water, thence into glass, thence into air again. In passing from air into the water, the light is seen to be bent, but is now bent *towards* the

perpendicular to the surface which it is entering, because the object, viz. the water which it enters, is more dense than the air which it leaves. As it enters the glass, it is observed to bend again. This time it also bends *towards* the perpendicular to the surface it is entering, because the glass is more dense than water. But after passing through the glass it passes into the less dense air, when it bends *from* the perpendicular, and bends much more than at either of the previous times, because there is much more difference between the density of the glass and air, than between the air and water or water and glass.

Fig. 56.

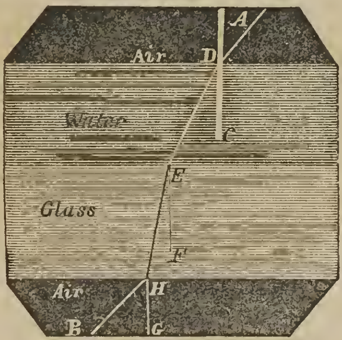


Fig. 56.—A, D, is a ray of light passing from air into the more dense water at D, where it is bent towards the perpendicular C, D. E, H, is the continuation of the same ray through the denser glass which causes the light to bend at E towards the perpendicular E, F. H, R, is the continuation of the same ray through the less dense air which causes the light to bend from the perpendicular H, G, and to a great degree because of the great difference in the densities of air and glass.

436. It is a rule of universal application that light in passing from a less dense into a denser object, is bent *towards* the perpendicular to the surface it is entering.

437. It is also a rule that the more the density of bodies differ, the more is light bent in passing from one object to another.

438. *There are therefore two things which influence the bending of light.* 1. *The direction in which it falls upon an object.* 2. *The density of the object.*

439. If now light pass in straight lines through the flat piece of glass C (Fig. 57), it does not change its course because it falls upon the glass perpendicularly to the surface, but when the light passes to the piece of glass L, made with rounded surfaces, the light will be bent as it enters the glass, because it does not strike upon the glass L, perpendicularly to its surface. It will of course be bent *towards* the perpendicular to the surface it is entering. When it has passed through the glass and enters the air it will be bent *from* the perpendicular, because it is entering a less dense object than it is leaving. The result is seen from the figure.

Fig. 57.

Fig. 57.—*a*, *b*, *c*, represent rays of light which pass through the piece of glass *c*, without being bent as they fall perpendicularly upon the glass *c*. But as they fall upon the lens L, in a direction not perpendicular to its surface, they are bent in such a manner that they all cross each other at the point *m*, which is called the focus, beyond the focus the rays spread farther and farther from each other.

440. The principle is perhaps better illustrated by Fig. 58 :—*a* represents a candle, with the ray of light (*a*, *d*) passing to a piece of glass (*d*, *k*) called a lens. As soon as the light enters the lens, it is bent towards the perpendicular (*e*, *d*) to the surface it is entering. When the light passes from the lens, the light is again bent, and is now bent *from* the perpendicular (*h*, *g*) to the surface of the air it is entering, and passes on in the straight line (*h*, *i*) until it shall meet some object which will *absorb* it, *reflect* it, or *transmit* it. Again, the light (*c*, *k*), as it enters the lens, is bent toward the perpendicular, and when it leaves the lens is of course bent from the perpendicular, and goes on in the straight line (*k*, *i*) till it meet some object. *Observe now an important thing:* the light (*a*, *d*, *h*, *i*) crosses the light (*c*, *k*, *i*) at a point (*i*), which is called a focus ; and it will be seen by Fig 57, that all the light passing to the lens between the outer rays (*a*, and *e*) will, by the application of the principles just mentioned, be bent so as to cross at the same point or focus (*m*).

Fig. 58.

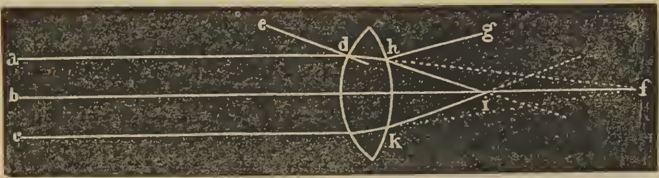


Fig. 58.—a, b, c, are three rays of light falling upon a lens; (b,f) falling perpendicularly upon its surface is not bent upon entering, and as it leaves in a line perpendicular to the surface it is not bent. The line a, falling at d upon the lens to which e, d is perpendicular, is bent toward that part of the perpendicular within the lens which the light is entering. When the light leaves the lens at h, instead of passing to f, it is bent from the perpendicular h, g, to the point i. It is understood that the light is passing from the lens into a less dense substance.

441. The problem is then solved, viz., if the light coming from any point be made to pass through a substance of proper nature and form, it will be gathered to a point.

In proof of this, let the reader try the effect of a sunglass, which is a simple lens, the surfaces of which are rounded or convex. If the light of the sun be allowed to shine upon the sunglass, and a piece of paper or any object be held upon the other side of the lens, by moving the object nearer or farther from the lens, at last it will be seen that the lens bends all the light falling upon it in such manner that the light crosses at a point. For if an object should be held in the light at the points 1, 2, 3, Fig. 57, it would make a smaller spot at 2 than at 1, and a smaller one still at m, and a larger one again at 4, just as the light passing through the lens does upon the object held in its course; for if this be held quite near to the lens, and then withdrawn slowly, the light will produce a smaller and brighter spot, till at last there is a mere point, when the spot will increase in size and diminish in brightness. If the experiment be tried with the light of a candle and sunglass, the result will be the same.

442. Suppose now, there are two points at a little distance from each other, as in Fig. 59, A, B, from which light is passing to a lens. By the application of the before-mentioned rules, the light will be found mingled on the front surface of the lens, but so bent as it enters the lens and passes from it, that all the light from A, which falls upon the lens, crosses at the point b, and all the light from B crosses at a. If an experiment be tried with a sunglass and two or more candles, the same thing will be proved, for it will be found that all the light from each candle will cross at the same spot it will if that candle only be lighted. Of

course, if the object receiving the light be held in the right place, the light passing through the lens will produce as many spots as there are candles.

Fig. 59.

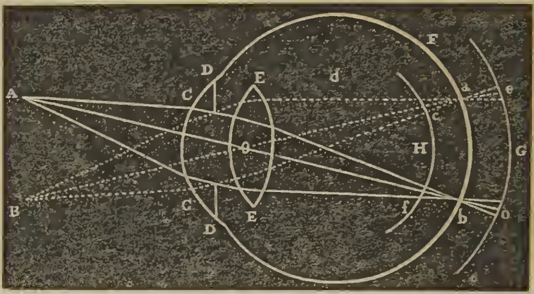


Fig. 59.—A, B, represent two points, of which there may be millions. From A, B, the light falls upon the cornea, *c*, *c*, and is bent as it is passing into the eye. D, is the iris; E, E, the lens, the small spot at which the central rays or axes from A and B pass, being called the centre of the lens. After the light leaves the lens it is observed to cross at the retina (*a*, *d*), while if the retina had been as far distant as G, or only as far distant as H, the light would have acted over considerable space.

443. If, now, we go back to the subject of ¶428, we shall readily see how to gain the desired end, viz., by placing a lens, as in Lith. Pl. 5, Fig. 2, so that all the light passing through the pupil of the eye shall pass through the lens; for by that means the light coming from any point of an object will cross at a certain point within the eye, and if the nerve be there, it will be acted upon by all the light coming from the given point of the object, and entering the pupil.

444 There are now two difficulties to overcome; the first is, what is called the "spherical aberration." It is produced as explained by Fig. 60; the light falling upon the surface of the lens near its edges, is bent more than the central light, because from the shape of the lens the light falls more obliquely or slanting upon the surface near the edges than upon the more central parts of the lens. Of course, the light passing through the outskirts of the lens will cross at a point or focus nearer the lens than the central light will; but it is desirable to have all the light cross at the same point, and it must be so arranged that all the light coming from any point of an object, and falling upon the lens, may act upon the nerve. This end is gained in three ways:

445. 1st. The iris (rainbow), or colored part of the eye,

Fig. 60.

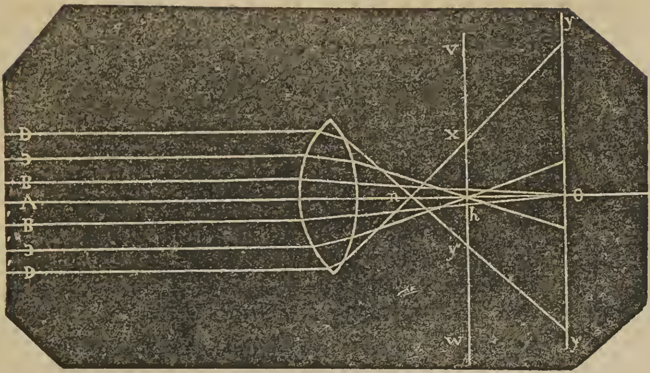


Fig. 60.—Exhibits the fact that A, O, falling perpendicularly on the lens, is not bent. B, *b*, are bent somewhat, and cross at *o*. C, *c*, are bent still more, and cross at *h*; while D, *d* are bent most of all, and crost at H.

represented by the partition *a*, in Lith. Pl. 5, Figs. 1, 2, prevents light from falling upon the edges of the lens.

446. 2d. The form of the lens, as found in the eye, is peculiar, and such (Fig. 61) as is adapted to the purpose desired, being more round, or more convex on the back or posterior surface than on the front surface.

447. 3d. By the peculiar structure of the lens, it is adapted to its purpose. It is composed of layers like an onion, and as represented in Fig. 61. The outer layers are almost liquid, the next like jelly in consistence, the middle of the lens being almost like gum-arabic for density.

The light, therefore, which passes through the central part of the lens, will, on account of its greater density towards the centre, be bent more than otherwise, and cross at the same point as the light passing through the outer parts of the lens.

448. The second difficulty to overcome is this: the different kinds of light are not bent equally by the same substance. If the light passing from the point *a*, Fig. 62, be white light, that is, composed of the three kinds, red, yellow, and blue, as it passes through a common

Fig. 61.

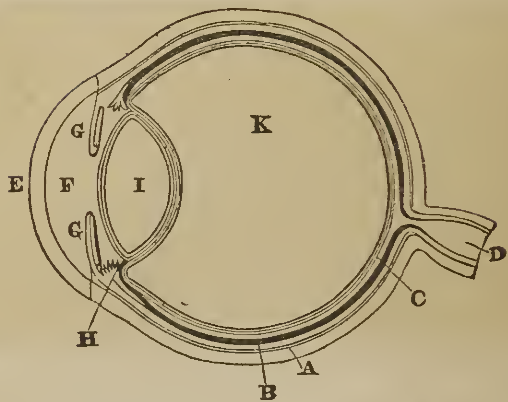


Fig. 61.—Cornea fitted into the sclerotic coat. A, Choroid. B, Pigmentum nigrum. C, Retina, lined by the hyaloid membrane, containing (K) the vitreous humor. D, The optic nerve. I, The lens. G, Iris, coated on the back side with pigment, (paint). H, Ciliary processes. F, Aqueous humor.

lens, it will be found that the blue light is bent the most, and crosses at a point nearer to the lens than where the yellow crosses, which is also nearer than the focus of the red light. But in the eye under ordinary circumstances, this does not take place. How it is prevented is not known. We may now pass to consider the structure of the eye, and its appendages, after which we shall be able to sum up the abilities of the eye, and have a clear view of what seeing is, and how it is accomplished.

449. First, the external appendages of the eye. The eye is placed in a deep and large socket. In this the eye is protected by a cushion of fat, in and upon which it is situated. It is also well protected from blows by the jutting forehead, the prominent nose and cheek bone; indeed, it is shielded in every direction, except directly in front and to the outside, where it can easily see, not only to take care of itself, but also the body.

450. The eyebrows also shield the eye in a measure

Fig. 62.

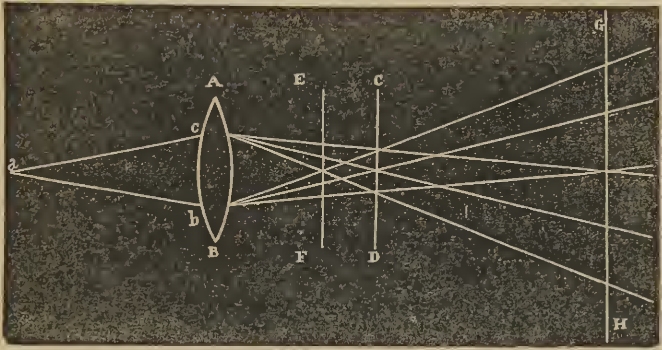


Fig. 62.—Shows that some of the light is bent more than the rest.

from the dazzling rays of the sun, and from the perspiration flowing from the forehead. They are nourished and caused to grow by the blood which flows around their roots. To insure a good supply of this, the skin at the eyebrows should be daily rubbed.

451. The eyelids close over the eye to exclude dust, to wipe off the dust which has been admitted, and to spread the fluid, called tear-fluid, over the eye. The movement of the lids is accomplished by two muscles. One is called the annular, orbicular, or ring muscle of the eyelid. It passes around the opening of the lids, as in Lith. Fig. 1, Pl. 1. When it contracts, it gently closes the eye. When forcibly contracted, it slightly draws inward the outer corners of the eyelids, as the muscle is connected to the edge of the orbit near the nose. The eyelid is raised by a muscle which commences at the back part of the eye socket, and passing over the eyeball, terminates in the upper lid just beneath the skin, and above the edge of the lid, as seen in Fig. 63. The form of the edge of the lid is preserved by cartilages, called the tarsi. They are curved to the form of the eyeball, but

keep the lids stretched from corner to corner. At the outer edge of the lids the eyelashes are found beautifully curved, in such way that when the lids are closed they may interlace, yet their ends be never entangled, as is seen in Fig. 64. Sometimes an eyelash will perversely grow into the eye. It should be drawn out of the lid at once, and if the one which follows it shall take the same course, as it probably will, that is to be treated in the same way. The lashes sometimes come out, and either the disease which causes them to come out, or their coming out, produces very bad results. The physician should be consulted in good season. The edges of the lids when closed, do not leave a groove at their back edge, as sometimes said, and as represented by Fig. 65. The lids meet at the back edge, but not at the front, as any person may satisfy himself by looking at the closed eye. Near the inner edge of the lids there are many small openings of tubes, which lead up into the lid and terminate in minute pieces of apparatus, consisting of coiled tubes, called Meibomian glands. In these is formed a kind of fatty substance, which, oozing down upon the edges of the lids, serves to prevent the tear-fluid from running over upon the cheek.

452. The tear apparatus consists of a small organ, about the size and form of a sparrow's egg, of a whitish-yellow color; situated above the eye, a little outside of the middle of the socket, and near its front edge. In this, the tear-fluid is formed from the blood. From this, which is called the lachrymal or tear-gland, from ten to fifteen very minute tubes lead down, and open into the eye through the inner surface of the upper eyelid, just above its inner edge. Through these, the eyes are moistened.

453. The tear-fluid is led off from the eye into the nose, through appropriate tubes. If the prominent point of the lids, seen near the inner corner, be turned out, a black speck

Fig. 63.

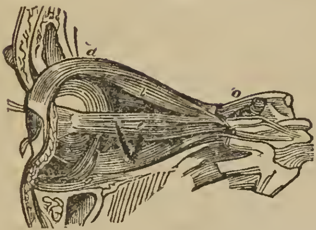


Fig. 64.

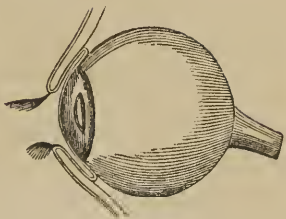


Fig. 64.—The left eye with the muscles of itself and lids, exposed by removing the outer part of the socket. *a*, The elevator of the eyelid (levator palpebrarum). *b*, The superior. *e*, The external, and *c*, the inferior recti (straight) muscles. *a*, The inferior oblique.

Fig. 64.—Represents the eyeball with the entering nerve at the back part. The curved lids are seen in front, and the skin covering the lids is observed to continue round the edges of the lids to line them, and then is reflected back, as it is called, upon the eyeball, over the cornea, and is continuous with the lining of the lower lids.

Fig. 65.

will be readily noticed. Upon further examination, it is found to be the opening of a minute tube, which curves around, and with its fellow from the other lid, opens, as seen in Fig. 66, into a large tube or canal, called the lachrymal or tear-duct. This opens into the nose.

454. The tears are of use, ordinarily, to moisten the eye, and afterwards the nose. When horseradish, mustard, and such things, "fly up into the nose," the flow of tears is increased in such a degree that they cannot be carried off into the nose, but gush over upon the cheek. The intention in this case is, that by flowing into the nose they shall remove the substances producing the trouble. The flow of tears is often increased by the emotions. Their use in these cases is not evident.

455. The tubes leading from the eye to the nose, are sometimes closed; the tears then constantly flow over upon the cheek, and the person by constantly wiping them away brings on soreness of the eye, which, in a little time, becomes very distressing and serious. A slight operation of inserting a small silver tube will remedy the whole evil. It

Fig. 66.

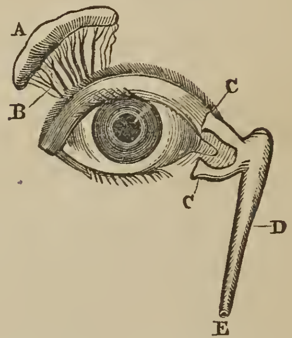


Fig. 66.—A, represents, but not correctly as it respects form, the lachrymal or tear-gland; B, the ducts or tubes leading from A, into the eye; C, C, the puncta lachrymalia, or the openings through which the tears flow from the eye into D, the lachrymal or tear-sac, which opens at E, into the nose.

may result from a cold, and pass away when the cold is removed. If it do not, let it be early attended to.

456. The lining of the eyelids and the covering of the eyeball, are very similar in their nature to the lining of the nose; indeed, may be considered as a part of the same thing extending through the tubes which connect the eyes and nose.

It is therefore seen, how liable the lining of the eye will be to disease, if a person take cold; both on account of its similar structure with the lining of the nose, and from its intimate connection with it. In ordinary, slight inflammation of the eye, experience has long proved there is nothing so generally good, as washing the eyes frequently with cold water. From the similarity of structure, it might be assumed that similar benefit would ensue from bathing the nostrils with cold water, by snuffing it. This is found to be the case in colds, catarrhs, &c. All those eye-washes, lauded so highly by their *conscienceless* compounders and venders, should be carefully avoided. If good for any thing, they cannot be worth what will be charged for them, and many a man has lost his eye-sight by the use of them, when he thought—if they did no good, they would do no harm. An inflamed, or sore condition of the eye,

should not be neglected as it is, too frequently, but attended to by some one who is responsible.

457. At the inner corner of the eye, and, as it were, between the ball and the inner corner of the lids, is a substance or part—small, but somewhat prominent. It is of a pale red in ill health, and a bright red in health. Upon its surface are the openings of small tubes, leading to an apparatus like the Meibomian glands, forming in considerable quantities a similar substance, which at times is seen collected at the inner corner of the eye. On the surface of this is seen, upon examination, a number of very minute hairs; which sometimes become large, and prove very troublesome—irritating the eye, &c. This must be prevented by drawing them out, and repeating the operation as often as necessary.

From the inner corner—though not from the part just described—a fleshy substance sometimes grows, and extends up over the ball of the eye. If this growth be very slow, hardly observable from year to year, and cause no soreness, it may be let alone. But if it grow fast, and extend up to the transparent part of the ball, and threaten to cover "the sight" or any part of it, it should be removed at once; and if it grow again, as is probable, it should be again removed.

458. The ball of the eye is moved by the action of six muscles. Five are attached (Fig. 67) by one extremity, to the deepest part of the socket; four of the five, called recti or straight muscles—as their name would indicate—come forward in a straight direction and are attached to the white of the eye, just back of its front edge.

One muscle is attached above; one beneath on the outside, and one on the inside. The contraction of these muscles draws the eye either upward, downward, outward, or inward; and two muscles acting at the same time, direct the eye in the intermediate direction—while the successive contraction of the muscles, will produce a rotary motion of the eye.

459. The fifth muscle, called the superior oblique, passes forward (as seen in Fig. 67) to near the upper edge of the socket, and nearer the nose than the centre of the socket,

Fig. 67.

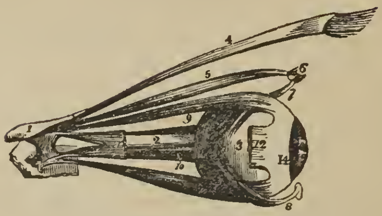


Fig. 67.—1, A small portion of the bottom or back part of the socket of the eye. 2, The optic nerve. 3, The eyeball. 4, The levator of the eyelid, with eyelashes attached. It is raised up from its natural position—to show, 5, The superior oblique passing through the tendinous loop 6. 7, Being a continuation of the tendon 5, and is attached to the eyeball near 3. 8, Is the tendon of the inferior oblique, attached to a piece of bone which forms part of the eye-socket near the roots of the nose. 9, The superior rectus. 10, The internal rectus. 11, 12, The external rectus, with a portion cut out that other parts may be shown. 13, The inferior rectus. 14, The edge of the sclerotic, where it is joined to the cornea.

where the tendon of the muscle passes through a tendinous loop, when it turns back and becomes attached to the upper, outer, and back part of the eyeball. When this muscle contracts, therefore, it rolls the eye inward and down, as when the eye is directed to the tip of the nose.

460. The sixth muscle, called the inferior oblique, is attached by one extremity to the front and lower part of the socket near to the nose. It then passes under the eyeball and becomes attached to it at its lower, outer, and back part. When it contracts, it tends to roll the eye upward and outward, causing it to look toward the outer end of the eyebrow.

461. It is thought that the contraction of the inferior and superior oblique muscles would tend to draw the eye forward, while the recti muscles by contracting would tend to draw the eye backward, thus suspending the eye as it were, and causing it to be moved with the greatest ease.

462. Sometimes one eye or both are drawn inward, sometimes outward. At one time it was thought that this was owing to the inner or outer muscle being imperfect—too short. Very many operations were therefore performed of cutting the muscle, supposed to be too short. But it was found to remedy the evil in only a few cases. The cause

of the evil was discovered, upon examination, to be a defect in the power of seeing, with the eye which was turned out of its natural position that it might not interfere with the vision of the other. Sometimes this defect is removed by the operations of nature, when in some cases the eye returns to its natural action, but in some cases does not. In these cases, and in those where the muscles are naturally too short, it will be proper to operate by cutting the muscle, the cut ends of which will be in a short time connected by an additional quantity of substance, which will make an addition to the length of the muscle. But if the eye be defective, the muscle, true to its duty, will again direct the sight of the eye inward. If a child be cross-eyed, the eyes should be examined, and if the vision be defective, let the mother remember that a good disposition and a cultivated mind will make her daughter more happy and more loved, and the means of more happiness to others, than if, without these, she were gifted with the fabled beauty of the Houries.

463. *The eye.* The outer part of the eyeball, from its color, is called the "white of the eye," and from its firmness is called the sclerotic (hard) coat. It has two openings, a large one in front, to admit light, and a much smaller one, a little to the inside of the back centre, to admit a bundle of nerves, called collectively the optic (to see with) nerve. From the form and structure of the sclerotic it yields but slightly, except to great pressure. It is about the thickness of common pasteboard, thicker, however, at the back than the front part.

The use of this spherical box, is to allow the attachment of muscles, the action of which properly direct the "sight of the eye;" to allow the nerves to enter from the brain, and the light which is to act upon them, to enter from the world; and to preserve from harm the delicately adjusted apparatus, which causes the light from any point of an object to act on the point of a single nerve. Sometimes the sclerotic is misshapen, for it is seen by Lith. Fig. 2, Pl. 5, that a certain size of box is necessary, that the focus of the light passing through the lens may be on the end of a nerve, found in the back part of the box. Sometimes the sclerotic is too deep, sometimes not deep enough. The remedy for this is wearing glasses, as hereafter shown. Sometimes the back part of the sclerotic is not perfectly well shaped, being irregular, in which case vision will be confused—for this there is no remedy.

The sclerotic is rarely subject to disease, but is frequently the cause of much pain when the parts within it are diseased. It is painful when pressed upon, for this is a danger to which it is exposed, and which it is to resist. It does in one way resist by the pain it produces, thereby calling the assistance of the mind to its relief. This may be tried by making pressure with the finger upon the eye. When the eye from disease is unnaturally full, as it would usually be in case of inflammation of any portion of the interior apparatus, the pressure made upon the sclerotic will cause a deep ache, becoming more severe as the cause acts more powerfully. To avoid using the eye, and to make application of cold, will be advisable. But the attention of the experienced physician had better not be neglected too long.

464. Lining the sclerotic, but scarcely adhering to it, and not reaching as far forward as it does, will be found a more delicate coat, or layer, called the choroid, the explanation of which conveys but little if any idea of the thing named. It is not half as thick as the outer coat of the eye. The surface next the sclerotic is a rich chocolate brown, while the inner surface is a deep black, that is, absorbs all the light falling upon it.

The use of the choroid is to form a support to the bloodvessels, some of which extend forward to nourish, and supply the wants, of the front parts of the eye ; and to form the coloring matter, of especial use upon its inner surface. Being the seat of many bloodvessels, it is especially liable to diseases of an inflammatory character, the treatment of which depends upon so many circumstances, that the most skilful physician will sometimes be in doubt. Ignorance only, will feel assurance, and promise uniform success.

465. The coloring matter upon the inner surface is so conspicuous, it is many times considered as constituting a distinct coat, called the pigmentum nigrum (black paint). It is very much thicker as it is examined at the middle and front part of the choroid and its appendages, than at the back part.

The use of this part is supposed to be to absorb the light, which might be reflected from one part of the eye to another, and produce indis-

tinct vision, as is evident would be the case if the light coming from one point of an object, were allowed to be reflected about till it should fall upon the domain of another object.

466. Within the last mentioned coats is found the nervous coat called the retina (net-work, from the supposed arrangement of the nerves when the name was given, a wrong idea, however). This is merely the divisions and terminations of the optic nerve, or rather it is the commencing points of the optic nerve, which as it leaves the eye, is doubtless composed of all the filaments commencing at the millions of nervous points presented in the eye, to the action of the light. A few of these are represented in Fig. 53. The retina is composed of a slight amount of other substance, serving to connect the nervous substance.

The use of the commencements of the nerves is to receive the action of light, the different kinds of which, by producing different effects, cause different sensations. The use of such a form as exists in case of the retina will be seen if the experiment of the sunglass with several candles be tried. The candles may be in a line, but the foci on the other side of the lens will not be found in a line, but it will be necessary to curve the objects upon which the foci are caught. It is also seen in Lith. Pl. 5, Fig. 2, that the foci produced by light passing through a lens, are not in a straight line, but in a curve. The peculiar form of the eye in respect to all its parts, is, of course, explained in the same manner. Thus, there must be the most beautiful and perfect adaptation of the various parts of the eye, both in their absolute and proportional size.

467. Within the retina, and filling nearly two-thirds of the cavity of the eyeball, is found what is called the vitreous (glass-like, not from its being as solid, but from its being transparent as glass) humor. It is composed of a membrane called hyaloid, (glass-like, from being very pellucid) which covers it entirely, and is arranged through it in the form of cells, which are filled with a very limpid fluid. The membrane does not adhere to the retina at all, but is connected with the choroid at its front part, by processes adapted to the

purpose. At its front part, it is hollowed out, or concave, to receive the back part of the lens, as represented in Fig. 61. Between the hyaloid and retina, but belonging to the retina, is found a network of bloodvessels, formed by the divisions of a bloodvessel, which enters the eye through the centre of the nerve. One branch of it extends through the centre of the vitreous humor.

The network upon the retina is represented by Fig. 68, and may be seen by closing one eye and directing the other immovably upon some object like a white wall, and moving a candle up and down near to the eye, upon either side.

Fig. 68.

Fig. 68.—The artery and its coarser branches found at the back part of the eye upon the retina.

The use of the hyaloid, and the fluid it contains, is to fill the back part of the eye with a substance which shall act in such a manner upon the light leaving the lens, that it shall produce a proper effect upon the nerve. But as light is acted upon differently by objects differing in their density, the proper action of the vitreous humor will depend upon its being of a proper density. If it be too dense, it will bend the light too much, and its focus will not be on the nerve, but near to the lens. If the vitreous humor be not sufficiently dense, the light will not be bent enough, and the focus will not be at the nerve, but the light will fall upon the nerve before it has arrived at its focus. In either case, vision will be indistinct. The density of the vitreous humor depends upon the hyaloid membrane forming the cells, and the fluid filling them. Either of these parts may vary in respect to their density. The evil of either kind is to be corrected by wearing proper glasses. But either the membrane or the fluid may lose its transparency in whole or in part, in which

case, as the light cannot pass through perfectly, more or less indistinctness of vision will be the result. Sometimes this state is lasting, while in other cases, a proper attention to health and the means for improving it, will be effectual. Most usually all attempts to improve vision, in such cases, will fail.

468. What has been said of the lens need not be repeated. It is situated in front of the vitreous humor, a part of it sinking into the concavity of the humor. It does not, however, adhere to the hyaloid membrane, but is kept in its place by appendages connecting it with the choroid, similar to the appendages which connect the hyaloid with it. They are called ciliary (like the eyelashes) processes. They do not, however, resemble them, but more resemble a plaited, narrow ribbon. The lens is composed of a capsule, or covering, and the substance contained within, differing in density as the centre is approached.

The use of the lens has been already set forth. But its use has been somewhat exaggerated, as it has been made to represent the entire apparatus, which causes the light to be properly bent. It does not perform all this duty; indeed, it does not perform the most important part of it. It bends the light somewhat, but its greatest probable use is owing to the different densities of its parts, as it thus corrects the spherical aberration. Its form, also, assists in the same matter.

As the utility of the lens is, however, to bend the light, to a greater or less degree, a greater or less density of the lens must affect its mode of action. If more dense than it should be, it will bend the light more than it should; if less dense than it should be, it will not bend the light enough. In either case, as seen in the case of the vitreous humor, the focus will not be at the nerves. The evil must be remedied by the use of glasses. If the different densities of the parts of the lens from the circumference to the centre are not what they should be, vision must be indistinct. If the central part be not so dense as it should be in proportion to the outskirts of the lens, the light passing through the centre will not be brought to a crossing point so soon as the light passing through the outskirts, and *vice versa*, as seen in Fig. 62.

The capsule of the lens is liable to diseases of various kinds, by some of which it becomes thickened, or loses its transparency. The same is

true of the substance of the lens. A thick, milky appearance of the lens, produces what is called a cataract. In these cases, the light not passing through the lens, vision is impossible or very imperfect. Sometimes the physician is able to remove the diseases of these parts; but to restore sight, it is usually necessary to remove the lens. This is called an operation for the cataract. It is not very painful, and almost always has a favorable termination. Glasses must be worn, as it is necessary for a lens outside the eye to do that for which the removed lens was intended.

469. We will now pass to the cornea. This is fitted into the sclerotic coat much as a crystal of a watch is fitted in its case, as seen in Fig. 61. It forms the front part of the eyeball. It is more prominent than the sphere would be, to which the sclerotic belongs, as is easily felt. It is perfectly transparent, as is the delicate skin or membrane covering it, and which is a continuation of the skin lining the lids and covering the front part of the sclerotic, as seen in Fig. 64. If put in alcohol, the outer part of the cornea becomes milky in color, while the inner part remains clear as before. This shows that the cornea, though it be thin, is composed of several layers, differing in their nature. It may be, that in this way the eye obtains its "achromatic" properties.

The use of the cornea is almost evident. It serves as a window to admit light. But as light must, from the convex surface of the cornea, enter it for the most part in a slanting or oblique direction, it will bend the light, and very much likewise, because the difference in the density of the cornea and the air from which the light comes is great. It is here indeed that the bending, or refraction, as it is called, of the light, is greater than any where else in the eye. But the density of the cornea may vary, when the effect it will have upon the light will be correspondent, and cause its focus to fall somewhere besides on the nerve. The bending of the light will depend also upon its form. The more round or convex it is, the more will it bend or refract the light.

The cornea, or the membrane covering it, may be affected with various diseases, in the course of which their transparency may be in part or wholly lost. It can sometimes be regained by proper treatment; sometimes it cannot. The covering of the cornea is so delicate, it is very

hazardous to operate on it with carelessly made eye-washes—made only to sell, and generally by irresponsible persons.

470. Between the cornea and lens is a space filled with fluid of a very limpid character, called the aqueous (water-like) humor. It is less dense than the cornea, and of course an effect will be produced on the light entering the humor, but the difference is very slight, and the effect also. The difference between it and the lens is greater, and of course the light is acted upon accordingly.

The particular use of this fluid is not evident, except it be to fill the space with a fluid in which the iris could act with perfect ease, and which by its nature was perfectly adapted to receive the light from the cornea, and pass it in a proper manner to the lens.

It is liable to become more or less dense than natural, when its defects must be supplied with glasses. It also sometimes loses its opacity, which it can regain, as a general thing. Its loss, as when the eye is cut, is very quickly restored.

471. The iris corresponds to the partition *a* in Lith. Fig. 1, 2, Pl. 5. It is the colored part of the eye. The opening is called the pupil ; circular muscular fibres about the pupil, by contraction lessen the size of the pupil, (Fig. 69). Radiating fibres, by contracting, enlarge the pupil, (Fig. 70). The iris divides the front part of the eye into two chambers, which communicate with each other through the pupil.

Fig. 69.

Fig. 70.

Fig. 69.—A front view of the iris, showing the circular fibres about the pupil.
Fig. 70.—A back view of the iris, showing the radiated fibres.

The use of the iris is to admit a greater or less number of rays of

light, and to prevent light from passing through the lens too near its edge.

Sometimes at birth, there is no opening through the iris. In this case it is but a slight operation to make one. Sometimes the power of enlarging or diminishing the pupil is lost. This evil can usually be remedied by the physician. Sometimes the iris is injured or affected by disease, or naturally is in such a state that an artificial pupil must be worn upon the eye. There are various diseases of the iris not worth while to mention, as they occur but seldom, and can always be best managed by the skilful practitioner.

472. Thus it is seen that all parts of the eye, from the cornea to the retina, and also the sclerotic, by its form and size, have an influence in producing the grand result, so frequently stated as necessary to be accomplished by the eye, viz., to cause all the light coming from any one part of an object to fall upon a single nerve and produce an impression, uninfluenced by light coming from any other point; for the instant the light from any two objects falls on the same nerve, that instant they become one object, for all power of distinguishing them is lost. For if (Lith. Fig. 6, Pl. 5) the light from *r*, *b*, act on two nerves, the light from *r* being red, and the light from *b* being blue, will each produce its peculiar sensation. But if the nerves be considered as one, the effect on it will cause the sensation of purple, and the light will not then appear to come from two objects, one yellow the other blue, but from one object entirely purple.

473. Suppose, however, the objects *r*, *b*, be brought so near each other as to act on the end of the same nerve, when small, as first supposed, or as represented in Lith. Pl. 5, Fig. 5, that instant they will appear but one, and cause the sensation of purple. This is what occurs when paints are mixed—suppose red and blue. The light falls upon them and is reflected, and the particles of red and blue are at a distance from each other when the mixing is commenced; the light from the different particles is reflected into the eye, and acts on the end of different nerves; but as the particles are brought, by the process of mixing, nearer and nearer to each other, the light from two different particles falls on the same nerve, and the two paints produce the sensation of purple. If now, the nerves of a person should be comparatively large, the light from the particles of blue and red paint would act on the same nerve before they were as near each other or were as thoroughly mixed, as in case of a person whose nerves were finer. Without doubt,

the nerves of some persons are coarser than those of other persons, and this is one way in which we may account for the difference of colors which different people experience when looking at the same thing.

474. Again, suppose the light from any part, on account of some wrong state or form of the sclerotic, vitreous humor, lens, aqueous humor, or cornea, which as before set forth may exist, arrives at the retina just before it crosses, as in Lith. Pl. 5, Fig. 3, then the light from *y*, which we will consider yellow, will act on some of the same nerves as the light from *b*, which may be considered as blue, and the light from *r*, which may be considered as red, will act on a part of the same nerves as the light from *y*. In this case, there must be two causes of confusion: 1st. The light from *y*, which should act on a single nerve, and would thus produce an intense effect, acts over several nerves, and produces but a slight effect upon any one. 2d. *The light from different objects acting on the same nerves, distinct sensations cannot be caused.*

475. Again, suppose from some wrong state of some part or parts of the eye, the light is bent so as to cross *before* it reaches the retina, as in Lith. Fig. 4, Pl. 5. It is seen that the same results are produced, the same indistinctness of vision as described in the preceding paragraph, but the causes are quite different.

476. Where the light reaches the retina before it crosses, the eye is called long-sighted.

In this case it is necessary to do something which will cause the light to bend to a greater degree, and reach its focus at the same instant it reaches its nerve. A convex lens is required for reasons heretofore seen. If this be placed before the eye, the light will be bent before it enters the eye, and the contents of the eye will do the rest, as seen in (Fig. 71). The convexity of the lens required, must depend upon how much the eye fails to fulfil its duty, for the less the eye bends the light, the more must the lens be called upon to do.

477. Where the light crosses *before* it reaches the retina, the eye is called short-sighted.

In this case a lens called concave will be required, and which operates to bend the light from the axis of the lens, instead of towards it, as in the case of the convex lens. Thus the light being bent out, if the expression may be used, as in (Fig. 72), the eye will bend it back again, and in such manner that it will cross at the instant it reaches the nerve. The degree of concavity of the lens must depend, of course, upon the

Fig. 71.

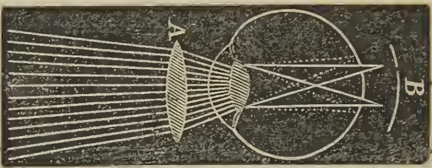


Fig. 71.—*A*, represents a lens causing the light to bend before it enters the eye, which is able to bend the light in the direction of the dotted lines, so as to produce foci at the back part of the eye instead of at B, as represented by the continuous lines in which the light would pass if there were no lens in front of the eye. The situation of the dotted lines is not correct, except in the fact that the foci are at the retina.

The light is here represented as converging when it falls upon the lens; this is seldom the case. It usually is diverging when it comes from any object to the eye, as in Fig. 72. When an object is very far distant, the light is generally considered as coming in parallel rays, as represented by Fig. 57, but it is seldom if ever the case that it is so. If it should be so, why should the light from different points of an object falling upon the entire surface of the lens, be brought to different foci? That different foci may be formed by the light coming from different points of an object, it is necessary that the rays of light from the different points should fall upon the lens with different degrees of obliquity, when, though they may fall upon the same point of the lens, a different direction corresponding to the obliquity will be given to them, and they will produce foci at different points.

degree of short-sightedness of the eye. The kind of glasses adapted to the eye is ascertained by trial.

478. Another matter may now come before the mind. If an experiment be tried with the sun-glass and candle, it will be found that the distance of the focus from the lens will vary with the distance of the candle, to wit, when the candle is carried to a distance from the lens, the focus is nearer the lens than when the light is placed near the lens. The reasons for this it is not necessary to discuss; the experiment proves the fact, as represented by (Fig. 73). If therefore, a nerve were at the focus of a distant object, it could not also be at the focus of a near object at the same time. But objects which are distant, and those which are near, produce distinct sensations in the eye if it be perfect in every respect. Yet the apparatus of the eye which bends the light, acts in the same manner as the lens used with the candle, as is seen in the case of long-sighted and near-sighted persons. For near-sighted persons bring an object which they wish to see, quite close to the eye, because when it is at a distance, the light coming from it crosses or forms its focus before it arrives at the nerve; but the nearer the object is brought to the eye, the farther from the lens is the focus formed, until it is formed at the nerve, when near-sighted persons can see. In case of long-sighted persons, the focus would be formed too far from the lens; and they

Fig. 72.

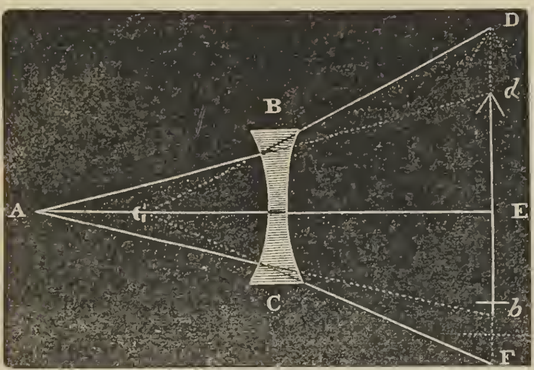


Fig. 72.—B, C, concavo-concave lens. Light in passing through it is observed to be bent from the axis A, E, as in case of A, D, A, F.

therefore remove an object from the eye, till at such a distance that its light will form a focus at the nerve.

Fig. 73.

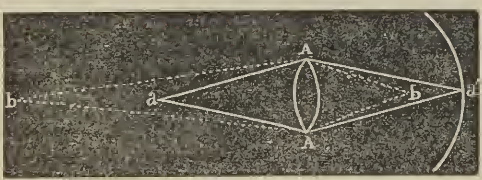


Fig. 73.—A, A, a lens by which the light passing from *a*, is bent to *a*, while if the object producing light be moved to *d*, the light coming from a more distant point is bent to a nearer point on the opposite side, as shown by the dotted lines.

479. It cannot be, therefore, that the eye remains the same when looking at a near object, in case of one who sees equally well objects at a distance. How the eye is altered is not however known. There are many hypotheses. If an experiment be tried with the lens and candle, such that the object upon which the focus falls remains permanent, as does the retina in the eye, and while the candle is removed from the lens, the lens be also removed towards the retina, if I may call it so,

the focus will be seen to remain always at the retina. When the candle is brought again towards the lens, the lens must be removed from the object. This, of course, is the same thing as if the lens should be permanent, and the retina should be caused to change place with the motions of the candle. On account of the results of this experiment, some have thought the apparatus which bends the light, is moved forward or backward, as we look at near or distant objects. Some have thought that the eye was made deeper by the pressure of the muscles when we look at near objects, by which means the bending or refracting apparatus of the eye would be made more distant from the retina. There are many objections to this. The sclerotic is very unyielding, and causes unpleasant feeling when pressed gently. Some think the lens of the eye is drawn forward when we look at near objects, and moved back when we look at distant objects. But there does not seem to be any means for accomplishing this duty, for it must be moved very much to accomplish the desired end. Others, again, have suggested that the adaptation of the eye was produced by the increased and diminished density of certain parts of the eye. Others have thought a change in the position of the lens in its place would give the desired result. Others, again, have said that the object was gained by the change in the size of the pupil, which will be noticed to diminish when near objects are observed. None of these three opinions can be correct, as is quite evident without remark. Some again have thought, that light coming from an object produced a variety of foci, to wit, that passing through the outskirts of the lens one focus, that passing through the central portions of the lens other foci. This is not so, as heretofore proved; but if it were, the conclusion would not be correct, which is this, that the light from a near object passing through the outskirts of the lens produces a focus at the nerve, at the same time that the light from a distant object passing through the centre of the lens produces a focus at the same nerve; for in this case objects in the same direction from the eye would have their foci upon the same nerve at the same time, and could not be distinguished. No theory yet suggested is valid.

480. There is, however, no doubt of the fact, that the eye possesses the power of adaptation, for people have it and lose it, as in case of those who become near-sighted, or long-sighted. This last is many times produced from not exerting the power. The sailor who is in the habit of using his eyes to look at distant objects, loses to a degree the power of examining near objects; while the student who occupies the most of his

time in reading, loses the power of seeing distinctly distant objects. This loss is to be prevented by seasonable and frequent attempts to look at distant objects; a persevering course of the same kind will enable a person to recover the power in many instances, though it has been lost for years. Except by sailors, it seldom happens that the power of seeing objects near at hand is lost until advanced age. The cause for its loss then, is not satisfactorily determined. It has been by many supposed to be owing to a flattening of the cornea, but there is a strong objection to this. True, the cornea is flattened in old people, but it is much fuller, as a usual thing, in children than in middle age; yet more middle-aged people than children are near-sighted; the power possessed at birth, being lost for want of exercise. How in extreme old age the power of seeing with the acuteness of youth is sometimes regained, cannot, with present knowledge, be explained.

481. The eye serves another very important purpose. By means of the eye we know the direction of an object from us.

To explain how this is done many theories have been advanced. I shall adopt that advanced by Volkman, for I cannot perceive any objection to it, though I have looked upon it with much caution, as Muller thinks it cannot be sustained.

If the reader will turn to Fig. 59, he will see, that the central lines drawn from A to *d*, and from B to *a*, pass through the same point at *o*. If there were a hundred objects with their light falling upon different points of the retina, a line drawn from the objects to the point acted upon, would pass through this point *o*. This may be called, therefore, the stationary point, for though the object and the point of the retina acted on may change, that point (*o*) remains the same. The precise position of this point depends upon the form of the lens. In case of the eye, it has been found by very accurate measurements, to be just back of the crystalline lens.

482. There is therefore always a point at which all the straight lines, drawn from objects to their foci, will cross.

483. If, therefore, a line be drawn from the focus through this point and extended, it will reach the object from which the light causing the focus has come.

484. Volkman therefore believes, and I think he is right, that we are so made or constituted, as to believe that an ob-

ject which causes light to act on a part of the retina, is in a straight line extended from that point through the stationary point.

In the same manner, when we feel a sensation which has been produced through any nerve, we believe the object producing the sensation acts on the part where that nerve commences.

485. Another question is, How do we know the distances from us of different objects, and the distance of these from each other? These questions have been answered in various ways.

486. In the first place, we learn by experience the distance of objects.

For instance, we learn that an object is twenty steps distant, by the fact that it requires the contraction and relaxation of certain muscles twenty times. This we know by sensation, as heretofore shown. If it require forty contractions, &c., of the muscles, to reach an object, we consider that it is twice as far distant as the first. Now when we look at the first object, a certain adaptation of the eye is necessary, that it may be seen distinctly; producing this adaptation produces a certain sensation. When we look at the second object, another adaptation of the eye is necessary, and this produces another sensation. Remembering these sensations, we shall think, when these are produced again, that the objects are at the same proportionate distance as before. Much experience, and often produced sensations, make us remember them, and we are therefore able to form good judgments of the distance of objects. A near object acts on a greater number of nerves than the same object at a distance. Thus we judge of the size of objects, first, by judging of their distance, and then of the number of nerves upon which they act. Such is my belief.

487. Thus, if all the nerves throughout the body were alike, the eye would be necessary, that we may know the direction of objects from us, and the distance and size of objects, when not in contact with us. Neither can the color of objects, by which they are distinguished from each other while at a distance, be known, without the eye. *To see, therefore, the eye is necessary.*

It has been made a source of exceedingly pleasurable sensations. These are usually produced by the combined action of certain colors. Hence it is very important, in selecting the colors of a dress, that the colors be such, that if they act at the same time upon the same nerve, and produce compound sensations, these may be agreeable.

488. There are in this connection two things worthy of particular notice. Certain objects transmit only certain kinds of light, and when these are reflected to the eye, mingled with other light, they produce a very unpleasant effect, while other objects transmit those kinds of light that, reflected from various objects, produce pleasant sensations, and render the objects attractive. I shall be understood by an illustration. Green paper curtains transmit mostly green light, or more properly speaking, yellow and blue. If this green light be reflected from a lady's cheek, it produces a very unpleasant effect. The person will look ghastly and unwell.

489. In the next place, the light reflected from objects a lady wears as dress, will be more or less mingled with the light from the complexion, and thus compound sensations will be produced, which will be pleasant or not, according to the dress. An example will illustrate. If a lady wear pea-green trimming, it reflects green light of course, and some of it being reflected to the cheek, will be reflected from the check with other light to the eye of another person, and an unpleasant effect will many times be produced.

490. These principles are also to be kept in mind, viz., that colors are judged by comparison ; and still more important, that when sensations of any strong kind are produced for any length of time, an unpleasant sensation is the result, however pleasing at first. Thus we become tired of "decided colors." It is in better taste, therefore, to dress in subdued colors. In regard to the point first mentioned, however, it is to be kept in mind that it is not the comparative color of an object, but the positive sensation it produces, which gives the pleasure. Thus a lady may wear a bit of court-plaster, that her complexion may appear white by contrast, but the positive sensation her complexion produces does not depend at all, or at most but very little, on the court-plaster. That affects merely what is said of her, not the sensation she can produce. Nature has never intended man or woman should pass for any thing other than what he or she is.

491. If it be asked how these principles can be made use of, the answer is, that a person must learn what compound sensations are agreeable, and surround herself with such articles of dress and furniture as will be pleasing by the effects they will produce ; for we always love those in whose society we find agreeable sensations produced, of sight or sound, or any other sense.

492. *It will be proper in conclusion, to speak briefly of images, optical instruments—such as telescopes, microscopes,* &c. All mention of

them has been purposely avoided, because much confusion is produced in the mind by the introduction of the indefinite term images, in language generally used where these subjects are treated upon, and so far as I can judge, the mind of the learner finds it difficult to conceive of an image of a dart in the eye when one is represented there in a drawing. There is nothing like the dart in the eye. The dart is that which acts upon the light, while the image is the light itself. To illustrate. If light be coming from a thousand different points of an object, it will arrive in the eye at a thousand different points or foci. These bear the same relative distance from each other as the points of the object from which the light has come, as seen in Lith. Pl. 5, Fig. 2. That is, if it be as great a distance from the first point of an object to the second, as it is from the second to the third, it will be as far from the focus of the first point to the focus of the second, as it is from the focus of the second point to the focus of the third point. The distance between the points of the object may be twelve inches, and the distance between the foci but half of an inch; it matters not, if the ratio of the distance between the foci be similar to the ratio of the distance between the points from whence come the foci causing light. These foci are called images of the points of an object from which the light has come, and the foci formed by light from all the points of an object are called the image of the object. Again, when light passes from an object to a mirror, it will be reflected entire. That is to say, whatever *kind* of light passed to the mirror, will be reflected from it, for the mirror does not change the nature of the light, but only the direction. If the mirror have a "true" surface, the light, as in Fig. 74, will be in the same relations *after* being reflected as before. It will, of course, make no difference how many times a single particle of red light, for instance, is bent in its course to the eye; acting by itself, it can produce but one effect on the eye, under any circumstances, and that will be the sensation of red. Its being bent only affects our belief of the direction whence it comes, which is, that it has come in a straight line, drawn from the point of the nerve, where the impression was produced through the "stationary" point; so, also, if the light of many different kinds, from many different points, produce many different foci, it will make no difference if all the light be bent, provided the light from all the objects be bent at the same time and in the same manner, by which the same relative distances will exist between the foci as existed between the objects from which the light came. An image is said to be produced at the mirror, but there is no more an image there than at any other point between the object and mirror, or

between the mirror and eye. For at any such point, the light exists in the same relations as when it left the object. And wherever the light from an object exists in the same relations as when it left the object, *there* is an image in an optical sense. It is not known to be there, till the eye be placed there, or an object which shall reflect the light to the eye without altering its relations, any more than the place of the focus of the light from a candle, passing through a sun-glass, is known till the eye be placed where it is, or an object be so placed as to bend the light to the eye; for the eye must either go to the focus or the focus must be brought to the eye that it may produce a sensation, without which its existence is unknown. But it will be said, perhaps, that the image appears to exist behind the mirror. Very well. It is readily seen that the light reflected from the mirror should appear to be produced in that direction, for it is so with all reflecting objects in nature. They reflect the light of the sun, for instance, yet the mind thinks nothing about the sun, and till taught, knows nothing where the light was produced, but believes it came from, and was produced, by the object *that last reflected it*. It may have been reflected a thousand times before, or not once; the mind is not influenced thereby.

Fig. 74.

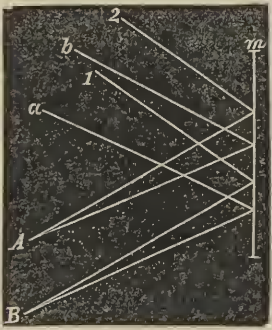


Fig. 74.—Represents light passing from the points A, B, to the mirror *m*, from which it is reflected or turned backward more or less, according as it strikes perpendicularly upon the mirror or in a slanting direction.

493. In the next place I have endeavored to show, that from experience the mind learns, or is constituted so as to believe, that when one adaptation of the eye produces a sensation, the object seen is distant;

and when another adaptation of the eye produces another sensation, the object is near. I have endeavored to show, that the reason why an adaptation of the eye was necessary, was, because the light from a distant object falls less obliquely, or slanting, upon the cornea, as seen in Fig. 73, than the light from a near object; hence, though in fact bent less than the light from a near object, it is not necessary it should be, and yet it will be brought to a focus, nearer to the lens than the light from a near object. Hence the adaptation of the eye will be required, not absolutely according to the distance of the object, but according to whether the light fall perpendicularly, or obliquely, on the surface of the cornea. If the object be near, and the light by glasses can be made to fall quite perpendicularly upon the cornea, the same adaptation of the eye will be required to cause the light to bend to a focus at the nerve, as if the light came perpendicularly upon the cornea from a distant object. It is seen by Fig. 74, that light coming from any point of an object after being reflected, passes in the same manner as before, viz., in a diverging manner; and of course, when it falls upon the eye, has the same obliquity to the surface of the eye, as if it had passed through the same distance without being reflected; and of course, the same adaptation of the eye is required, that the focus may be at the nerve. Consequently, the light seems to come, as it does, from the direction of the mirror; but from a much greater distance, and hence seems to be behind the mirror. An image then—in an optical sense—is not a picture, not a representation, not an outline, but is an arrangement of light which has come from an object; not the object, nor the shadow of an object, nor the painting of an object: all these things will cause light to produce the same effects as an image would; indeed, will cause light to become an image—optically speaking.

494. It is desirable many times to obtain more light from any given object than will fall upon the cornea, and enter the pupil. In a dark room, there may be light enough coming from the objects to produce on the nerves slight sensations, but so slight, the objects cannot be seen distinctly. Two ways may now be taken, to make the object more distinct; either admit light to the room, or gather more of the light coming from an object, and cause it to enter the pupil. This last can be done by means of a large lens, as seen in Fig. 57. Without this, the light is so feeble that only six rays of light, for example, can enter an opening the size of the pupil; but one hundred rays fall upon a large lens, which will so bend them that all the hundred can enter the pupil, and act on the end of the same nerve, as seen in Fig. 57, that six only acted upon

before—the sensation becomes much more intense of course. This is the grand principle upon which a telescope or microscope is constructed. It will be seen, however, that another glass or lens is required; as the light which has passed through the large lens, called an object-glass, is so bent that if it fall on the cornea before it reach the focus, it will be too perpendicular to the surface of the cornea, as seen in Fig. 57, supposing the cornea should be placed at 2. If the light, after it has passed the focus, fall on the cornea, it will be too oblique to be bent by the eye in such a manner that its focus may be at the retina. Such evils are corrected by a convex-glass, placed beyond the focus; the light in passing through this is bent to a degree, and the eye can accomplish the rest (Fig. 75). Other glasses are added, to obtain minor benefits, the nature of which may be better learned elsewhere. In case of a microscope and magnifying-glass, much the same principles operate.

It is desirable to have a great deal of light from a small object enter the pupil. If an object be held very near a lens, a great deal of light from a few points will fall upon it, and fall very obliquely—hence it will be very much bent; but if the distance of the object be right, not so much as to pass to a focus, but to go to the eye in parallel lines—as in Fig. 57. Suppose *m* to be the object, and the light to pass from it through the lens. If the object be too far from the lens, the light will be bent so as to cross; if the object be too near the lens, the light will not be bent enough to form parallel rays—and in either case the eye could not cause the light passing from the lens into it, to form a focus at the retina. The distance of the object from the lens, will of course depend upon the convexity of the lens. In this case, represented by Fig. 58, some of the light falling upon the lens, does not enter the eye. But if the lens be very convex and the object brought very near the lens, a great deal of the light passing from any point of an object, must fall upon the lens, in the first place; and by the convexity of the lens, it will be so bent as to produce a focus. In this case, however, there must be another glass between the object-lens and the eye, for the same reason there must be in case of the telescope, viz., to bend the light in such a way, that in passing through the eye, the bending powers of the eye may bring the focus upon the retina. By the application of principles, previously laid down, it is easily seen why an object viewed through a telescope, should appear so near; and why an object seen through a microscope, should appear so large. Reflecting telescopes, camera obscuras, and the like, are made with only a variation of the application of the principles mentioned. The grand principle being, to cause the light from an object to bend in

such a manner that a large amount of light may so fall upon the cornea, that the refracting apparatus of the eye may cause it to act on a single nerve and produce a distinct impression, which will cause a distinct sensation.

Fig. 75.

F. *The Sense of Hearing.*

495. The ear is the organ of this sense. By means of the ear, distant objects cause sensations.

For if the ear be perfectly closed, sound is not caused by surrounding objects. By experiment it has been found, that if a bell be shaken in a glass from which the air has been removed, sound is not caused by the bell, but the instant the air is admitted the usual ringing is heard. It follows therefore, that,

496. Surrounding objects act upon the air, and cause the air to produce effects upon the ear.

These effects are called impressions, and acting through the nerve of hearing and the brain, they cause sensations.

497. Four things are necessary that sound may be produced. 1. An object to act upon the air. 2. The air to be acted on by the object, and then to act on the ear. 3. The ear, including all its connectives of nerve, brain, &c. 4. The mind.

498. The sensation produced or the quality of sound will depend, therefore, on the nature of the object, the character of the air, the nature and condition of the ear and its connectives, and the mind.

499. So far as we can learn, the nature of objects is always the same under similar circumstances. It is exceedingly different in case of different objects, or the same objects under dissimilar circumstances. Al-

most every object in nature has a voice, distinguishing it from every other object, even of its own kind, in every other respect. There are millions of the human family, more numerous still are the beasts of the field and of the forest, besides almost innumerable birds and a tenfold number of insects; but the blind man distinguishes the voice he has ever heard; each sheep knows the bleating of her own lamb, and every bird the call of its own mate. It would be as difficult to find two objects producing precisely similar sounds, as for the child to find two similar blades of ribbon-grass, which every one has probably tried in vain.

If the hand be placed upon a ringing bell, a jarring feeling will be produced. This is owing to the motions of the particles of the bell, for though it seems so solid and thick, its substance is thrown into very rapid but not very extensive motions. If a tuning-fork be struck and brought near the eye, its rapid motions will be perceived. If the eye be directed to the strings of the piano or violin when played, or if the hand be laid upon them, their rapid motions will be at once perceived. If a tumbler be struck, a similar effect will be produced.

500. Vibrations is the name given to the motions of objects when they are acting to produce sound.

501. If a tumbler containing water be struck, the water will be thrown into waves by the action of the vibrations of the tumbler upon it. If air instead of water were in the tumbler, the vibrations of the tumbler would throw the air into waves similar to the waves of the water. In the same manner the strings of the violin, the guitar, the piano, the head of a drum, &c., produce waves in the air in contact with them. When a cannon is fired, a heavy bell rung, or the deep tones of an organ played, the waves are so powerful as to jar the body in a very perceptible manner, to rattle the windows, or in case of the cannon, to break the glass. If the fingers be brought near the lips of a person while speaking, the waves produced by the voice will be noticed; hence,

502. All sound-producing objects, by vibrating, act upon the air and throw it into waves.

503. The peculiar character of the waves will depend upon the vibrations producing them, and the state of the air in which they are produced.

504. If a stone be dropped into water, waves will be noticed to flow out in a circular direction from the point acted upon. It will also be observed, that the waves grow smaller the greater the distance from where

they commenced, until at a certain distance the water is undisturbed. If the water be calm the waves will flow in a circular manner, but if the water be running in any direction, the waves will extend to a greater distance in that direction, and the waves instead of being circular, will be more or less oblong. It is the same with the air, except that the waves of air are spherical; they pass off in all directions, growing less and less, and extending farthest in any direction with a current of air than against it; thus,

505. The air-waves produced by the vibrations of sound-producing objects, act through the ear upon nerves and cause impressions.

The nearer the object producing the sound, all other things being similar, the more powerful the impression. If the wind be blowing towards the ear from the sound-producing object, a more powerful impression is produced than if the wind be blowing from the ear towards the object; hence,

506. The more powerful the wave of air, all other things being equal, the more powerful the impression.

507. We learn also, that, other things being similar, the more powerful the impression, the nearer is the object producing it.

508. If a stone be dropped in the water near the perpendicular face of a rock or aught else in the water, the waves will be seen to strike against the rock, and then be apparently sent back, or reflected, as the expression is; and as they go backward they grow smaller and smaller, to the same degree precisely as if the rock had not been there, and the waves had gone on in a straight line; that is to say, if the stone were dropped into the water three feet from the rock, and caused waves to strike against the rock and flow back, when they had gone back one foot from the rock, they would be of the same size as those waves which had gone in another direction, and found nothing to obstruct them when they were four feet from where they were produced. Thus it is with waves of the air; if a person fire a pistol, the waves it produces striking against a steep hill, bank, ledge, house, or the like, will be sent back; by the time they reach the person's ear, however, they will be very small, and produce but a slight effect or impression. As this is feeble, the cause of it, viz., the pistol, will appear to be a long distance off. This is what is called an echo. It seems to a person as if a pistol were fired a long dis-

tance off, and in a certain direction, viz., in that direction from which the waves come to the ear.

509. We judge any sound-producing object is in the direction from which the waves of air it produced came to our ears.

510. The states of the air affecting the character of its waves, depend upon its temperature, its degree of moisture, and its density.

Upon these it will not be worth while here to speak, farther than to say, these different states of the atmosphere modify considerably the effects which vibrating objects produce upon it, and of course modify the effects it produces upon the ear. Before passing to consider this organ, I cannot forbear expressing the astonishment that almost confounds me, when I think of the innumerable variety of waves which may be produced in the air—the simple air. It sometimes seems as if it could not be so.

511. The ear is a complicate piece of apparatus or mechanism, for the purpose of causing the air-waves to act in a proper manner upon the commencing points of the nerves of hearing.

512. The external ear is so well known as not to need description or remark, except that it is uncertain whether it is of much assistance in hearing or not. Some persons, who have lost it by accident or disease, have not felt its loss. By others, it is thought of much importance.

513. From the external ear, a tube leads into the head, from half an inch to an inch and a quarter, when it is closed by what is called the membrane of the tympanum (drum), or sometimes, the outer drum-head.

514. This tube is protected by hairs found at its commencement, and by what is called ear-wax. This is found in follicles or cryptæ, viz., little pouches with openings upon the surface of the tube. They are similar to those forming the oil upon the skin, and the mucus of the mucous membranes. It is sometimes formed very rapidly, collects in the ear-tube, hardens, and causes a greater or less degree of deafness. When deafness is produced by this cause, it can be removed by dropping into the ear a few drops of sweet oil, and retaining it a short time with a bit of cotton, chewed paper, or the like, when the oil and any collections

in the ear are to be removed by a thorough syringing with castile soap and warm water. It is said that many cases of deafness are thus cured, and many others very much relieved. It is here seen how much people are imposed upon, who are induced to buy at great expense a small bottle of ear-oil, which cannot be better than sweet oil and probably is not as good, while the chief good is all the while to be derived from the syringing with soap and water, viz., from cleanliness.

515. The membrane which closes the end of this tube, passes downward and inward slightly, as seen in Fig. 76. Its utility depends upon its flexibility. It is necessary it should be acted on by the slightest wave of air which comes down the tube.

516. Passing through the membrane of the tympanum (drum), we arrive in the tympanum (B, Fig. 76.) This is about the form and size of a kidney bean ; it is filled with air. Opposite the outer drum-head are what are called the inner drum-heads, viz., two openings (2, 3) closed with membranes ; one is of an oval form, and called the foramen ovale (oval hole) ; the other is called the foramen rotunda (round hole). They will again be noticed. At the back part openings are found, leading into what are called the mastoid cells, viz., cells in the mastoid bone, which is found and may be felt just back of the ear. The use of the cells is not known. They are supposed in some way to facilitate the power of hearing. At the lower part, the drum of the ear terminates in a small tube, called the Eustachian tube, which leads down into the back and lower part of the nose, or into the upper and back part of the throat. Through this the air has a free passage to and from the ear, and any substance can pass this way from the ear-drum.

517. The lining of the nose extends up through the Eustachian tube, and lines the drum of the ear, and of course the drum-heads, and also lines the mastoid cells.

518. Any disease, therefore, affecting the throat or lining of the nasal cavity, would easily extend to the Eustachian tube, and through

Fig. 76.

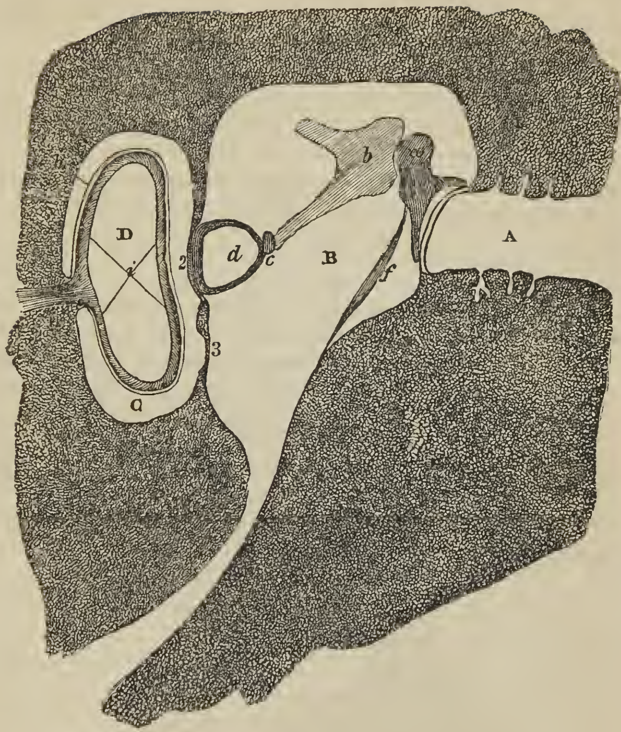


Fig. 76.—Is an ideal representation of some of the principal parts of the ear. The dark dotted part corresponds to the bone. A, represents the tube leading inward from the external ear. The skin which covers the ear is seen lining the passage, the membrane at the bottom of the ear-tube, and also the pouches, sacs, or cryptæ, on either side. The sacs are not, however, in the bone as here shown, on account of being so much magnified. The sacs are thousands in number, and form the ear-wax. B, represents, but not in form or size, the drum of the ear. At the lower part a tube, representing the Eustachian, is seen leading into the nose, and lined with a continuation of the lining of the nose. *a*, *b*, *c*, *d*, The four bones connected upon one side with the external membrane, and on the other side to the membrane (2) leading into the labyrinth. *f*, is a muscle, the use of which is not well determined. C, may be taken to represent the labyrinth filled with fluid and containing the sac D, which is also filled with fluid. The nerve of hearing is seen coming through the wall of bone surrounding the labyrinth, and dividing and subdividing with its points towards the inner surface of the sac, as seen at the extremities of the lines with which *i* is connected.

that to the lining of the ear-drum and produce derangement of the hearing apparatus, and hardness of hearing. Hence why colds, catarrhs, scarlet fever, attended with soar throat, and the like, are so apt to produce transient or permanent deafness.

519. In the first place, the tube is so small that any little thickening of its lining will close it. This may take place and the sides of the tube not adhere, or they may grow together. To know if the tube be closed, compress the nostrils and shut the mouth, then blow with force. If the tube be open, the air will be forced into the drum B, and distend the membranes outward. This will produce a sensation of feeling, and usually a crackling, or a rumbling sound. If the tube be closed, nothing of the kind will take place. To know if the tube be permanently closed, it will be seen by Fig. 77, that a probe may be passed along the floor of the nasal cavity to its back part, when the probe, if turned inward and downward at the outer extremity, will be turned upward and outward at its inner extremity, and enter the tube. This by the skilful physician can be readily done. If the probe can be passed into the ear-drum without causing pain, time after time it can be done, and with the use of larger probes, till at last the opening will remain when the probe is removed, and the air is again allowed a passage into the ear, and the collections of the ear a passage out. In such a case, very great care must be taken to avoid colds, as the slightest causes will tend to close the tube again.

Fig. 77.

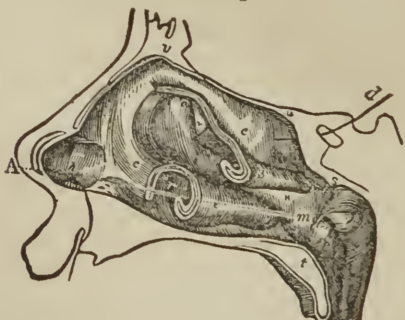


Fig. 77.—Represents a section of the nose upon one side of the division or vomer; the turbinated (coiled) bones are seen with a portion removed. The line A, m, extends to the opening of the Eustachian tube, m.

520. If the tube be permanently closed, it has been sometimes proposed to make an opening through the external membrane. By this means, air of course would be admitted to the drum of the ear, but there would be no chance for the collections of the ear to pass off, and the result of such experiments has proved unsatisfactory.

521. The membrane lining the ear-drum, and also the mastoid cells, is subject to a variety of diseases. Its lubricating fluids are not formed in sufficient quantity at times, and the membrane becomes dry, and where it covers the drum-heads, it would, of course, diminish their flexibility. Again, at times the fluids of the ear-drum are formed in superfluous quantities, and injury ensues. The lining of the drum is thickened and the consequences are bad, etc. If hardness of hearing depend upon want of flexibility of the membranes, it can be determined, many times, by the history of the case, and by the kinds of sounds heard most distinctly. If a child's voice be heard readily, while the low voice of manhood is heard with difficulty, the hardness of hearing may be attributed, in many cases, to inflexibility of the membranes. The physician can, in many cases, by proper injections and attention to the *general* health, restore health to the lining of the ear-drum. It is sometimes very beneficial where the membranes are inflexible to close the nose and mouth, and then alternately blow the air into the ear-drum, and allow it to return. This will throw the membranes into motion, and by frequent repetition tend to give them suppleness. If, however, the slightest pain is thus produced, the course should not be pursued.

522. An arm of a small bone called the malleus (hammer), *a*, is attached to the membrane, just below its centre, as seen in Fig. 76. The head of the hammer is attached to another bone called the incus (anvil). This has by some been thought to resemble a tooth with two fangs, one larger than the other, and considerably separated from it. To the longer branch or arm of this bone, a very small bone, called the orbicularis (round bone), *c* is attached. By some it is considered as a part of the anvil-shaped bone, as it is inseparably attached to it after the period of childhood. It is only about as large as the flattened head of a pin. The fourth bone from its form, called the stapes (stirrup), *d*, is attached to the round bone by one part, and exactly covers the oval hole (2, Fig. 76).

523. The bones are jointed together in such a manner as to move upon each other. When, therefore, the slightest movement is produced in the first membrane, it will be communicated to the chain of bones

Fig. 78.

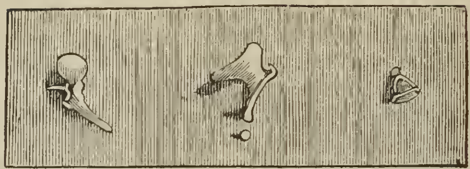


Fig. 78.—The bone of the ear, 1, malleus (hammer), 2. The upper one is called incus (anvil), the lower one orbicularis (round). 3, Stapes (stirrup).

Fig. 79.

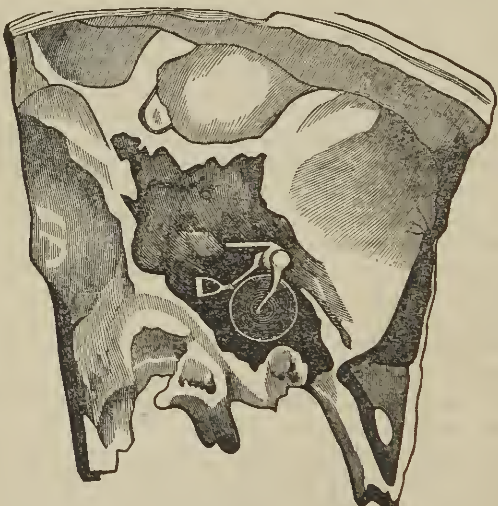


Fig. 79.—Represents a section of the bone containing the drum of the ear in which the bones are seen.

stretching across to membrane 2. Each movement of the first membrane will, therefore, act upon membrane 2.

524. It is, however, certain that persons have lived and enjoyed their hearing well where the bones were wanting. They are not, therefore, *absolutely* essential. By some it is thought that hearing is *usually*

produced by the communication that takes place through the air, between membranes 1 and 3. Others think that communications will always be made through the air between 1 and both 2 and 3, and that the bones are merely of use to produce a proper state in the membranes, in respect to tensity, etc. Others again think that communications are made from 1 to 2 by the bones, and from 1 to 3 at the same time by the air. Others think that, ordinarily, communication is established by the bones, but when the bones are wanting the air is the medium. It is, therefore, by no means certain how beneficial or necessary the bones are. There is no doubt in my mind that they are of use, and that want of proper motion at the joints where they are united, renders hearing indistinct; and to preserve facility of motion between the bones, the same things may be recommended as in case of inflexibility of the membranes.

525. A muscle, worthy of note, extends from the vicinity of the Eustachian tube to the hammer. By contraction, it can make the membrane 1 more or less tense.

Some suppose that the membrane must be tuned, so to speak, to the various waves acting upon it—for instance, that the waves producing an acute sound, are met by a tense state of the membrane; while a wave producing a low or gruff sound, is met by a lax or slackened state of the membrane. It is uncertain.

526. The membranes covering the oval and round holes, called also fenestra (windows), separate the ear-drum from the labyrinth. This is worked out of the very solid bone, and consists of three parts, called the vestibule (porch), semi-circular (half-circle) canals, and the cochlea (snail-shell) (Fig. 80, and Fig. 81).

The particular use of these parts is not known. The general principle by which hearing is produced, can be better obtained from Fig. 76, where a circular box represents the entire labyrinth.

527. The labyrinth is lined throughout with a skin or membrane, adhering closely to the bone by one side; but very smooth and delicate upon the other, like the free surface of a serous membrane. Upon this surface is poured out a limpid fluid, called the aqueous (watery) humor of the ear. It fills the labyrinth.

Fig. 80.

Fig. 80.—The labyrinth; V, ventricle; O, foramen ovale; R, foramen rotundum; A, A, ampullæ; x, z, semicircular canals; K, cochlea.

528. In the midst of this fluid, in the vestibule and semicircular canals, is formed a membranous bag or pouch, taking the form of the parts in which it is found; but not touching the sides of the labyrinth, except at certain parts, as at y, Fig. 76, where the lining of the labyrinth is reflected, as it is said, to form the external layer of the bag. The bag is filled by a fluid similar to that outside of it, and formed by its inner coat or lining. The sac, however, is exceedingly delicate, and has been compared to the retina of the eye for delicacy, but is more firm.

529. In this sac sometimes, and in the fluid outside of it, a powder, like powdered bone, is found. Sometimes it is so coarse as to resemble sand, or collected so as to form tiny stones.

Its, or their use, is not known.

530. The nerve of hearing passes to the bag and also to the lining of the labyrinth in the cochlea, where it divides and subdivides, terminating, as some say, at the very surface —or perhaps, as others say—projecting a little into the fluid,

Fig. 81.

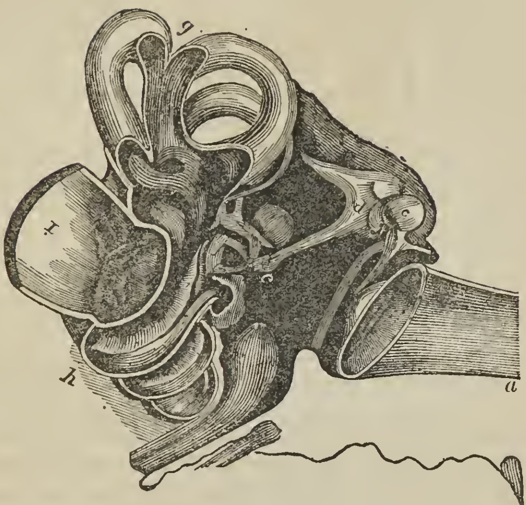


Fig. 81.—Section of the labyrinth, drum of the ear, and external tube a—closed by a membrane, to the inner surface of which the hammer c is attached; d, the anvil; e, the round bone connecting the anvil with the stirrup; g, the semicircular canals; h, the cochlea; i, the passage of the nerve.

and as it seems very near the surface, in delicate papillæ, represented by x, in Fig. 76.

531. The movements of either or both membranes, will produce waves in the fluid of the labyrinth and its inclosed bag; which dashing upon the surfaces containing the points of the nerves, will cause impressions as various as the producing causes.

532. The minute circumstances to be regarded in producing perfect hearing, are not understood. It is however evident enough that a proper supply of proper fluid is necessary. It is probable that this, like most if not all other fluids in the body, is undergoing constant change by frequent removal and as frequent formation by the lining of the labyrinth, and the covering and lining of the bag. If it be either removed or

formed too rapidly, defective hearing must be one of the consequences. It may likewise become too thick, or by some disease of the inclosing bones or membranes, it may be allowed to flow out, when hearing would of course be lost. The membranes also, in which the nerves are distributed, may become thick and affect hearing.

533. To know whether the contents of the labyrinth be affected, a watch may be placed in several positions on the affected side of the head. If the ticking be heard distinctly, assurance is had, that the labyrinth and its contents are not affected, for the bones of the head conduct the vibrations of the watch to the labyrinth. But if all be silent, hope is lost. Hearing, as dependent on the condition of the nerve, will be spoken of hereafter.

534. With such a multitude of causes to affect hearing, it is no wonder that we find many people deficient in this respect, or that deafness often baffles the skill of the most skilful, or that the ears which hear well should yet have such imperfection, that there should be a slight difference in the sounds produced through the different ears of the same person. The wonder is, that the ears should be so generally perfect. The most hasty glance at this subject will convince any one, that as there are so many causes of deafness, those who warrant or advertise their oils as *sure* cures for deafness, are unpardonably ignorant or most arrant scoundrels, or probably something amphibious in this respect.

535. I cannot better conclude this sketch of the ear, than by quoting from Le Cat's most excellent treatise on the senses. "Life, deprived of sensations as valuable as those of hearing, would be a kind of premature death. The deaf man is necessarily a dumb man, and who can compute his loss? His never-sleeping guard* that warned him of a thousand dangers is dead. And now, the crash of the falling tree, the scream of the drowning child, the tread of the midnight thief, and the mutterings of the coming storm, fall on his ear as vainly as the tear of sorrow on the brow of death. Who can compute his loss? The sweet echoes of the valley, the voice of friendship, the hallelujahs of the Sabbath, and the loud artillery of heaven, are alike condensed into barren nothingness, and in the very excess of stillness he loses all the pleasures of solitude."

* Not quite correct, for the sense of hearing is at times "hushed in death-like sleep."

SECTION 4.—*The Nerves of Sensation.*

536. These are white pulpy cords extending from the organs of sense to the brain. They look very much like the nerves of motion, heretofore described.

Some think the nerves of motion terminate in the nerves of sensation forming loops and a circuit with them. But, as often said, the commencements of the nerves are so minute, it is impossible with present means, to learn how they commence. The word commence is used, because in ordinary cases, the portion of nerve found in the organ of sense is the part first acted on.

537. It is the duty of the nerves to be acted on by certain causes, and then to act on the brain and cause sensations.

When the right kind of objects act on the organs of sense in a healthy condition, an effect is produced at the brain, if the nerves be entire, healthy, and not compressed; but the instant the nerves extending from any organ of sense to the brain are cut, or compressed, or diseased in certain ways, no effect can be produced by acting on that organ of sense. This shows that nerves are the agents through which effects are produced on the brain, and will also teach what particular nerves are agents in the production of any particular sensation. For instance, there are two nerves extending from the lining of the nose to the brain. If one be cut the animal cannot smell, but feels pain if the lining be pricked, while *vice versa,* if the other nerve be cut while the first remains entire the animal cannot feel pain if the lining be pricked, but can smell as well as ever. This teaches that one nerve is the nerve of smell, and that the other is the nerve of common feeling.

538. Some causes act only on certain nerves, while other causes act on other nerves.

For, as just shown, the nerve of smell produces no effect when it is pricked; so the cause, which through some nerves produces tickling, produces no apparent effect on other nerves. Light can and does act through the outer layer of the skin, but without producing an effect of sensation.

539. Some causes act upon all the nerves, or upon

several, producing different effects and causing different sensations.

Electricity, as it is called, will act upon the nerves passing from the organ of taste, and the sensation caused is the same as if a person were tasting something. If it act on the nerve of smell, a sensation of smell is perceived. If it act on the nerve of hearing, a sensation of sound is produced. If it act on the nerve of sight, the sensation of light is produced. If it act upon other nerves, other sensations will be produced. If a person falling, strike the head violently, the jar acts on several, perhaps all the nerves, so as to produce sensations, differing in case of the different nerves; thus a person "sees stars," hears a sound, perceives a smell, and through other nerves has sensations of pain, of "jarring," &c., produced. From the previous paragraph as well as this, it follows, that as some of the nerves are acted upon by causes having no effect on other nerves, and as, when the same cause does produce effects through different nerves the effects are different,

540. The different nerves are differently constituted, and are intended to produce certain kinds of sensations, whatever may be the causes acting upon them.

This is an exceedingly interesting and important proposition, and a few more illustrations may be brought forward. If a nerve in the finger be pricked, it produces a sensation of pain; but if the nerve of smell be cut, it causes a sensation of smell; if the nerve of taste be pricked, it causes a sensation of taste. If the nerve of sight be cut, as is sometimes necessary in extirpating the eye, a sensation of a great flash of light is caused. If the eye be pressed, two sensations are at once produced through two different nerves. Pressure through the eye on the nerve of sight produces a sensation of light, while pressure on the nerve of common feeling, extending from the eye to the brain, produces an unpleasant or painful sensation.*

* Thus it is seen that the nerves are so made, that the sensation of light can only be produced through the *nerve* of sight, and through its agency only can a person see. It has been seen in a previous section, that a person distinguishes objects only by the color of the light they cause to act on the nerves, and by the direction in which the light comes, for which purposes the eye is necessary. Since the eye and nerve of sight are both necessary that a person may see, how absurd it is for persons to pretend to see through the pit of the stomach, their fingers' ends, the top

541. There is one other respect in which the nerves are peculiar. Some causes act only at the commencement of the nerves, other causes act upon any part brought within the sphere of their influence.

If any peculiar temperature act on the commencement of a nerve it produces effects, but only by acting on the commencement. For instance, the temperature acting on the foot produees an effect on the brain, but the nerve extending from the foot to the brain is acted upon by a great variety of temperatures at different points, but they produce no effect. How wise this provision is! Had it been otherwise, the variety of sensations produced through any nerve would have entirely confused the mind, and no idea of the state of the foot eould have existed. If, however, the same nerve be cut, a sensation will be produced similar in all cases, whether the nerve be cut in the foot or in some other part of its extent. It is thus with all the nerves; viz., eut them in any point of their eourse, and they will produce like results as if eut at any other point. If electricity act on the nerve at any point of its course, it produces the same result as if it acted at any other point of it.

To sum up the whole matter, therefore, it is seen that some objects act on one nerve and some on another, while some things act on all the nerves; that some causes act on the nerves at their commencement only, while other causes can produce effects if they act on any part of the nerves; and that,

542. *The kind and degree of effect produced on the brain*

of the head, &c., as some impostors assert they do. Says Muller—"So long as a magnetic patient manifests merely the ordinary phenomena of nervous action that are seen in other disorders of the nervous system, it is all credible enough; but when such a person pretends to see through a bandage placed before the eyes, or by means of the fingers or the epigastrium (upon the stomach), or see round a corner and into a neighboring house, or to beeome prophetic, such arrant imposture no longer deserves forbearance, and an open and sound exposure of the deception is called for." That such things may be done, it should be remembered, not only must a *person* be magnetized, but also the laws by which the Creator has ordained that *light* shall be governed. It is to be hoped as we attribute the ignorance of our ancestors to the times in which they lived, and pardon them for believing in witches, and hanging those who wero "*plainly proved* to be leagued with the Prince of Darkness," that a more enlightened future generation will not reflect too severely on their forefathers for their credulity in respect to *clairvoyants*, quack pills, &c., of the present day.

by any nerve, acted upon at any *point by any cause, depends on the* NATURE and STATE *of the nerve acted on*.

543. The *nature* of the nerve determines the *kind* of effect produced when action of the nerve is produced.

For instance, the nerve of hearing cannot produce a sensation cf light, neither can the nerve of sight cause a sensation of sound, and the other nerves are by their nature able to produce only their peculiar kinds of sensation. Each nerve of any class of nerves can of course produce a variety of sensations, but all of one kind; that is to say, every nerve of the class is able to produce any sensation that any other nerve of the class can, for the instant any nerve produces any sensation or is the agent in producing any sensation, which another nerve cannot produce, it must be classed separately from the other nerve. For instance, all the nerves of sight can produce the sensation of light and all the varieties of that kind of sensation, but cannot produce the sensation of sound; while all the nerves of hearing can produce the sensation of hearing, but cannot cause the sensation of light; and though the nerve may have its condition altered so as to produce different varieties of sensations of its own kind, and with different degrees of intensity, if a nerve act at any time it must produce sensations of its own kind.

544. The *state* of the nerve will determine the *degree* and variety of effect it will produce on the brain.

545. The state of the nerve is either natural or cultivated.

546. *Natural.* The state of one person's nerves is naturally such that a slight cause produces a powerful effect The state of another person's nerves is such that a powerful cause will produce only a slight effect. In other persons slight causes act through some nerves and produce intense sensations, while powerful causes act through other classes of nerves without much effect. Persons do not, therefore, perceive similar sensations under the same circumstances.

547. *Cultivated* or *artificial.* Disease will alter the state of the nerves to such a degree that sometimes they produce sensations without the action of any other cause. For to produce a sensation it is not necessary that any thing act on the nerve,—only a certain state of the nerve. Usually, to be sure, some cause acts on the nerve and produces the state which causes the nerve to produce an effect on the brain; but if disease pro-

duce the same or a similar state of the nerve, the sensation will be produced. To illustrate ; wood, coal, oil, spirits, slaking lime, or aught else may be used to cause water to boil, it matters not. The water boils when it is in a certain state, viz., when it is hot enough, and whatever brings it into that state will cause it to boil. So a disease, a cut, electricity, or the more usual cause, may cause a nerve to produce a sensation ; if acting on the nerve any where, they produce a certain state. Sometimes disease does not produce such a state that sensations are produced, but such a state that a slight cause will produce sensations. To illustrate again ; if the water be very hot, only a little wood will be necessary to cause it to boil. Thus a student by much study and neglect of exercise, many times produces such a state of the nerves of sight that the action of only a little light proves very unpleasant. Diseases in some instances produce such a state of the nerves, that very powerful causes produce only slight effects. Diseases are so peculiar in their effects, that the state of the nerve necessary to produce certain *varieties* of sensation is very easily produced, or with great difficulty. That is, the nerve of sight is very easily acted upon by causes of certain colors, the nerve of hearing by causes of certain sounds, certain kinds of odors easily produce a powerful effect, or vice versa. These nerves are deficient only in respect to certain varieties of sensations of the kinds peculiar to each. Some persons are thus affected naturally or by disease, very early in life, and to such a degree that certain colors do not produce any or at least not a usual effect, and they "see things differently from other folks." Others are affected in such a way they do not hear certain sounds at all, or smell certain odors, etc , etc.

548. Medicines produce like effects with those described. Some medicines will produce such a state of the nerves that the slightest cause will excite sensations, or, perhaps sensations will be produced without any other cause, or, on the other hand, produce such a state in the nerves that no effect, or but slight effect, can be produced by the most powerful causes. This is, of course, highly beneficial when it can be done without retarding nature in her efforts to produce a cure. The slamming of doors, and all the like aggravations of disease, of course are comparatively harmless when the state of the nerves is such that but a slight sensation can be produced.

549. Various kinds of food, and indeed, the whole manner of living, will either exalt or depress the state of the nerves in such manner that the sensations will be easily or with difficulty produced. Thus it is in our power to produce, within limited bounds, such a state of the nerves, that the causes acting upon them shall produce such sensations as are desirable.

Let us now give our attention to the kinds of nerves, viz., those which produce similar sensations.

550. *a.* The first pair of nerves of sensation is called the olfactory. They extend from the brain forward over the nose, where little branches pass down through the sieve-like holes in the bone forming the roof of the nose, and terminate, or rather commence in the lining of the nose, as heretofore described, and represented at Fig. 82.

Fig. 82.

Fig. 82.—Represents a section of the nose parallel with its natural division. From 4, a line reaches down to the olfactory nerve, or what is sometimes called the olfactory lobe of the brain. From it the nerves are seen passing through the cribriform (sieve-like) portion of the ethmoid bone. The other portions do not need mention.

Properly speaking, however, that which extends from the brain over the roof of the nose, should be called a part of the brain, or the olfactory lobe of the brain. It is in fishes the largest portion of the brain. The branches which come down into the nose should be considered as the nerves of smell.

551. *b.* The second pair of nerves of sensation, are the nerves of sight, called the optic nerves. When they leave

the eyes, they seem as if composed of millions of fibres collected in one bundle, and covered with a sheath, which is continuous on the one part with the dura-mater of the skull, and on the other extremity with the white of the eye. It is supposed that every nervous point in the retina is the commencement of a nervous fibre, which assists to compose the optic nerves.

452. A little back from the eyes, the nerves from each eye meet, and a part of the fibres from each pass across, viz., that half of the fibres towards each other pass across between each other, when the nerves go on to the brain, with which they do not immediately unite; but as if *there were a necessity for them to produce effects at a certain part of the brain*, they wind around and terminate at the inner, middle and lower parts of the brain (Fig. 83).

Fig. 83.

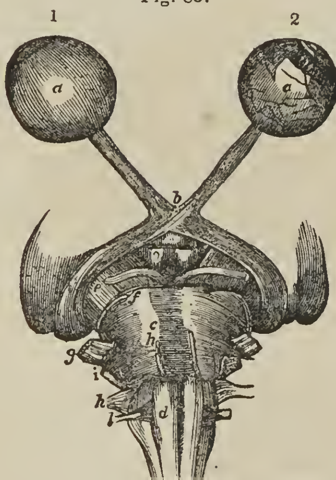


Fig. 83.—1, The external or sclerotic coat of the eye with the cornea at the front part. 2, The choroid coat with the ciliary processes at the front part. *b*, The commissure of the optic nerve, showing the crossing of the nervous fibres. The lower portion of the brain—the commencement of the spinal cord, and the roots of the nerves, are easily recognized.

553. *c.* The third pair of nerves of sensation commence at the ears, and are immediately brought in contact with the nerves called facial, which are nerves of motion; by the side of these they pass back to the brain.

554. *d.* The fourth pair of nerves of sensation are called the nerves of taste. But at present it is not determined which nerve is the nerve of taste. Some suppose one, some suppose another; there being several nerves commencing in the tongue, which extend to the brain, and experiment has not yet decided to which to give the preference.

555. *e.* The nerves of the muscular sense are very numerous, and are so combined with the nerves of common feeling, that they may be considered as part of them, so far as it regards their structure, arrangement, and terminations at the brain.

556. *f.* The nerves of common feeling. These are very numerous, and in fact embrace several kinds of nerves, which are called by the same general name, either because their duties are not worthy of particular notice, or because they are so blended with other kinds of nerves that it is not possible to distinguish them by experiment or examination. Indecd, in most cases they are so similar to the nerves through which motion is produced, and so blended with them, that it is not possible to distinguish in the greater part of their course, the nerves of feeling from the nerves of motion. Indeed, till within a few years, it was thought that the same nerves fulfilled two agencies at once, viz., that they were the agents for producing motion, and also sensation.

557. The nerves of common feeling—including the nerves of the muscular sense—commence, so far as can be judged, in every part of the body, each nerve in its particular part.

Not excluding those parts in which commence the nerves already mentioned, and called for distinction sake—special nerves of sense; they being nerves for the especial purposes already signified. In some parts of the body, however, the nerves, if they exist, cannot be seen; and the only proof of their existence is, that they are the causes of sensation—which, from what is known, is supposed to be always produced through the agency of nerves.

558. Immediately after the nerves commence, they begin to unite with each other in such way that they are found by the side of each other, but yet distinct from each other; and in the same manner, they unite with any nerves of motion in their vicinity till at last large trunks are formed, which may be traced into the back-bone, or through the skull into the head, as the case may be.

559. Within the back-bone, the nerves divide into two parts called the anterior (front), and posterior (back) roots, (Fig. 84). Here, but a few years ago, Sir Charles Bell and Magendie, by experiment, discovered the double nature and duties of the nerves. If the front root of the nerves of a frog's leg be cut, he cannot move the leg, because he has no means of communicating a contraction-causing-influence to the muscles of the leg; but the frog appears to suffer pain, if the leg be pricked.

Fig. 84.

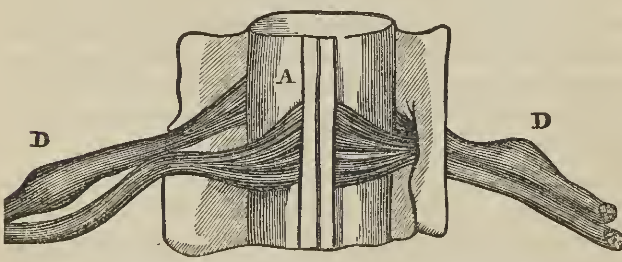


Fig. 84.—Represents the double roots of a spinal nerve, with a ganglion D on the back or posterior root.

560. If the back root of the nerve be cut, while the front root is entire, the animal can move the leg, but feels no pain when the foot is even burned. These things show that the front roots are the agents through which motions are produced, and the back roots the agents through which the sensations are produced.

561. The posterior roots unite with the spinal cord, at a line produced by the gray substance coming to the surface of the cord, as in Fig. 43. The anterior roots unite with the sides of the front parts of the cord in the neck; but as they unite with the cord lower down, they unite with it more in front.

562. After the nerves of sensation have united with the spinal cord, it is impossible to trace them to the brain; and the only proof that they extend to the brain, is found in the proof that the brain is the seat of the mind, which distinguishes every part of the body in which an effect is produced on a sensitive nerve.

563. Some have supposed that they could distinguish two parts in each half of the spinal cord. Sir Charles Bell thought he had proof, that in the neck at least, there are three columns, as he termed them, in each half of the cord, viz., the front column, the back or posterior column, and a middle column, called the respiratory tract. Those of this opinion think the front column is composed of the nerves forming the front roots of the nerves, the agents in producing motion; and that the back column is composed of nervous filaments from the posterior roots of the nerves, the agents in producing sensation. But there seems to be such an interlacing and blending of nervous filaments in the spinal cord, that it is not possible for any anatomist, however skilful, with present means, to separate the different nerves composing the cord.

564. On the posterior root of each of the nerves entering the back-bone, is found a collection of reddish gray substance called a ganglion.

The use of this part is not known. By some it has been considered as a nervous centre in which some effects are produced on the nerves passing through it, or in which terminates or commences some effect. There is no substantial proof of any of the hypotheses so liberally ad-

vanced, and though a mortification to one's pride, truth compels the acknowledgment that their use is unknown. They are found on nearly, if not all the nerves of general sensation.

565. Thus it might be expected, as is the case, that injury to the spinal cord at any point would prevent any sensations from being produced by the parts below, and this might be of such a character as to affect either one class of nerves, or the other, or both. The injury might affect one side only of the spinal cord, or both sides, or it might one class of nerves on one side and the other class on the other side. If the injury affected only a few fibres of the cord, a corresponding effect would be produced. If the cord were injured in the neck, it would not be expected that the nerves entering the head would be included in the injury.

566. If again, any such cause as disease or injury affected the nerves of sensations in their course through the cord, so as to produce certain states of the nerve, sensations would result necessarily.*

Section 5.—*The Brain as an Organ of Sensation.*

567. The first duty of the brain as an organ of sensation, is to produce effects which may be perceived by the mind, and which are called sensations.

Whether the brain can produce any effects on the mind, which are not felt, is not, and of course cannot be known. We know that persons

* From the remarks in this section it might be inferred, that compression of a nerve would prevent any thing acting on the nerve below the compressed point from producing any effect. This is certainly correct. The sensations caused when a nerve is compressed, are owing, not to any effect produced on the organs of sense of the nerve, but to the state produced in the nerve by compression. It might also be inferred, that compression of the proper nerves would prevent pain in case of surgical operations. I am not aware that any experiments have been tried which would show whether any benefits could be obtained from such a course, nor has any opportunity occurred for experiment, since the idea suggested itself, except on animals, in which case no pain seemed to be produced by pricking, cutting, or even burning the foot, the nerves of that part being compressed. Compression of the nerve in case of neuralgia, has been suggested and tried, in case of neuralgia—and it would seem that in some cases amputation, &c., might be done with less pain, the nerves being compressed.

speak to us without our knowing it. The vibrations of the voice of the speaker must reach the ear, and through the ear effects must be produced on the nerve of hearing, and it would seem that through the nerve effects must be produced on the brain, but whether any effect is produced on the mind and not noticed, or whether the effect stops with the nerve or the brain in such cases, is not known.

568. The first duty of the brain is proved by the important fact, that sensations depend upon the state of the brain.

If a person be stunned, the state of the brain is such that sensations cannot be produced. Some diseases, such as apoplexy and many other "fits," some medicines such as opium, intoxicating draughts of alcohol, &c., produce such a stupor of the brain, that sensations cannot be produced. On the other hand, inflammation of the brain, and various medicines, in small or large quantities, produce such a state of the brain, that the slightest causes will produce powerful effects.

569. The manner in which this duty is performed is not known.

Some suppose that the nerves through which various parts of the body cause sensations to be produced, do themselves act on the mind; that in other words, those parts of the brain through which sensations are produced, are composed of the nerves through which sensations are caused. Others suppose that these nerves do not act on the mind, but on distinct parts of the brain, which hold communion with the mind, and transmit effects to it which vary as the effects of the nerves vary. Others again suppose, that the nerves terminate at one part of the brain, it may be large, or it may be small, which part is acted on differently by every different state of the nerves producing effects thereon, and that this part transmits effects to the mind. These last suppositions involve unnecessary considerations, it seems to me; besides, I cannot conceive how the various parts of the body can produce such distinct sensations as they do, without nerves extend from every point capable of producing sensations to the mind itself. I therefore suppose that,

570. Those parts of the brain concerned in producing sensations caused by any part of the body, are the cerebral (brain) extremities of the nerves of sensation, which produce effects on the mind according to their nature and state.

The same remarks which applied to the nerves, in Sec. 4, will apply

to the brain in the fulfilment of its present duty; for so much of the brain as is under present consideration, is but the continuation of the same nerves there spoken of. Indeed it will make no difference in relation to the application of those remarks, what philosophy is chosen, though it will perhaps do no harm to repeat, with slight variation, the principles there laid down; for all will agree that,

471. If the brain be acted on, the effect produced by it on the mind will depend on its nature and condition.

472. Whether its nature, as it regards sensation, differs in different persons, cannot be ascertained;* but it has been gifted with certain powers by the Creator, which it cannot transcend.

573. The condition of the brain is partly natural and partly artificial. One person is so constituted that slight causes produce intense sensations, and no cultivation will entirely change this inclination of his system. Another person is so constituted that the most powerful causes may act on the brain, and yet cause but slight sensations.

574. An artificial state or condition may be either transient or permanent. Many medicines produce a transient effect on the brain such that causes act very easily, or on the other hand, with difficulty, or even such a state of the brain that sensations will be produced merely by the state of the brain. The effects caused by the use of alcoholics till delirium tremens are produced, is a terrible proof of this. The brain is in such a condition, that it will cause sensations of sight and sound never caused by aught in this beautiful world; and the pitiful object of such visitations believes himself surrounded by demons, from which he in vain attempts to escape, for the cause of his sensations is in his poor abused brain, which the Creator has intended shall be the agent in the production of unspeakable delight to those who observe his laws, which is *not to obey*, but to seek our highest good.

575. It matters not to the mind, whether the sensation be produced by the brain, or through the brain, the channel through which the mind is acted on being the same, every sensation seems a reality; and when, as hereafter seen, the brain is in such a condition, the mind cannot use it to reason with, and the mind is left unprotected to the torment of brain-produced sensations.

576. If the brain be inflamed, so slight a cause as the pulsation of the blood will produce sensations, perhaps of sight, of sound, of smell, taste, &c.; while the use of opiates can produce such stupor, viz., inabil-

* The brain is now spoken of merely in reference to sensations.

ity to produce sensations, that the most powerful causes cannot produce sensations.

577. A permanently artificial state of the brain is caused by the use of medicines, by continued diseases, and by continued habits of living. An overloaded stomach for a single time, produces an obtuse state of the brain for a short while only; but constant overfeeding dulls the senses permanently; while wholesome food, air, drink, clothing, and regular, reasonable, common-sense habits of every kind, will tend to perfect the state of the brain, and render it an active agent in the production of agreeable sensations.

578. It is therefore evident, that whoever is unhealthy, or uses articles as food or drink, or in any way so acts upon the brain, as to produce an unhealthy or unnatural state of the brain, cannot form a good judgment, as the sensations which will be produced are not healthy and natural, and his mind will be acted upon by agreeable or disagreeable sensations, but not such as would be produced by objects acting through a perfect brain. And upon any trial, it will be found that a man's judgment will be influenced very much by the sensations produced, not only by the thing under consideration, but by any thing.

579. It will, therefore, be exceedingly difficult to find persons who will think alike on the same subjects, or any person who will be uniform in his feelings or opinions; for his mind has such a changeable brain and nerves through which to receive sensations, that if itself be always the same, it must form very different opinions at different times, the testimony is so different at different times.*

580. It is especially worthy of notice, that a person is under obligation not to unfit his brain for producing natural sensations, by the use of such articles as poisonous alcohol, tobacco, etc., or by any such course of life as unfits him for judging correctly of himself or others, and of the world. To illustrate; a person by the use of tobacco produces such an effect upon his brain and nerves, that he cannot form a correct

* It will be found that people form favorable opinions of almost any thing which is presented to them, when they are acted upon by causes of agreeable sensations. Hence the custom of "feeding" our legislators when a request is to be made of them. And as first impressions are so strong and lasting with most people, it is always preferable to present a new topic before the mind, in connection with something which with certainty will produce agreeable sensations. And if a disagreeable thing must necessarily be brought before the mind, let it be combined with something which will produce agreeable sensations.

judgment of how offensive his breath is to others, who certainly have a right to receive the common air, pure and uncontaminated. A person who has used alcoholic beverages, has unfitted, for the time, his brain for producing disgusting sensations, such as his deportment and conversation produce through a brain unclouded by the effects of poisons. He will often so much mistake, as to think himself exceedingly agreeable ; indeed, be so much deceived as to think the exhilaration which he has produced, gives brilliancy to what he supposes accomplishments, but which an undeceived mind would look upon as awkward at best, but exceedingly clownish when exaggerated by dissipation.

581. The second duty of the brain is to cause the sensations to appear to be at the commencement of the nerve through which they are produced.

If a nerve be pricked in the finger, the sensation appears to be in the finger, and we say, it seems to us that the finger is pained.

582. The object of this is to call attention to the part exposed to danger.

If the finger be injured, it is necessary to call attention to the part injured, that the cause of the injury may be removed.

583. If the disease or cause producing injury be not found at the commencement of the nerve, it must be in the course of the nerve, between its commencement and the brain.

If the elbow be struck, two sensations are produced, one of acute pain, which appears to be at the elbow where the cause is acting, and the other of a prickling character, appears to be in the little finger ; but the cause of the sensation is not there, but at the elbow in the course of the nerve. If certain diseases affect the spinal cord, some of the nerves composing it will be so acted upon as to cause sensations like the creeping of animals ; these sensations will *appear* to be at the commencement of the nerves through which they were produced. A person frequently has " chills run over " certain parts of the body, owing to effects produced on certain nerves in some part of their course. In fever and ague the nerves in some part of their course, perhaps the spinal cord, are so acted on as to be in the same state as if their commencing points were affected by cold ; the person feels as if his skin were cold, and goes to the fire to warm the nerves, but his hopes are vain. It is disease, not

any want of heat, that causes the state of the nerves producing the sensations he feels.

584. The seat of disease is determined in these cases, by examining, in the first place, the parts in which disease appears to exist: if they are healthy, it must exist in such a part as to affect all the nerves extending from the parts *apparently* affected, to the brain; and as the part where the nerves from these parts come into each others' vicinity, is known, the disease is at once located.

Hence in neuralgia, when the pain seems to be produced, now here, now there—"darting about"—it would be natural to conclude, that the disease existed at some point where it affected all the nerves, extending from the parts where the pain *seemed* to be produced and the brain. If the pain be confined to any particular part of the body—as the face—the seat of the disease must be comparatively small; while if the pain seems to range over the entire body, the seat of the disease must be more extensive. The same comparative course would be pursued, and the same comparative judgment formed, if the disease be such that no sensations are caused by certain parts of the body; the cause of the paralysis must be looked for at such part where it will include all the nerves from the paralyzed part.

585. There are two exceptions to the proposition of paragraph 581: 1st, some sensations appear to be produced at the commencement of nerves which have been in no way agents in producing the sensations. Thus disease of the liver is apt to cause sensations to appear to be produced under the shoulder. In "hip complaint," the first sensations of pain seem to be in the knee, while the nerves extending from the knee to the brain, as far as we know, are not affected in any way. Why this is so, is not known.

586. The second exception is in case of many sensations, such as hunger and thirst. These and the like, do not appear to be produced any where in particular; nor is it known by what part of the body they are caused. Some have supposed they were produced by the stomach; and a variety of other suppositions, equally groundless, have been made. They are for the purpose of causing us to eat, drink, &c., and of that general character having reference to the good of the entire body, that there is no necessity for their being produced, or seeming to be produced, by any particular part.

587. There is another class of sensations produced by the action of the brain upon the mind when we think, but a proper place for discussing these briefly, is in another chapter.

Sec. 6.—*The Mind in respect to Sensation.*

588. What office the mind performs in the production of sensations, is uncertain. Some suppose that the mind itself, in itself, is capable of producing sensations similar to those of sight, &c., produced ordinarily by the action of the nervous system. Some suppose that the mind is capable of acting upon the nervous system, so as to produce those states which cause sensations; but that by itself, it cannot cause sensations. Some have supposed that the mind was of different qualities in different persons, so that if the same state of the brain should be brought to act on the different minds, similar effects would not be produced on account of the different constitution of the minds. Some have thought that different states of the mind were produced by the different states of the brain; and that also, these different states of the mind could be produced without the agency of the brain; consequently that all the sensations of sight, &c., could be produced in the mind of the person, blind not only, but wanting the *nerves* of sight. All these, and a hundred like questions, I readily confess my inability to solve; but from all the proofs afforded by physiology, I am inclined to think that,

589. Sensations are never produced, except by action of the brain upon the mind; and that the character of the sensation depends entirely on the state of the brain, because,

590. 1st, I cannot find any good proof that sensations are ever produced except when there is an opportunity for the action of the brain upon the mind. When a person dreams, there is not only an opportunity for the brain to act, but late suppers, and other such causes as tend to produce certain states of the brain, are the most frequent causes of dreams.

591. 2d, When certain states of the brain are produced, such that it cannot act on the mind, the mind does not realize sensations. The brain has frequently by accident been exposed, so that it could be pressed; the instant pressure was made, sensation was suspended, and when the pressure was removed, sensation was again produced; so perfect would be

the suspension, that if every thing remained in the same place, during the pressure, without the person's anticipating it, he would neither know it had been made, nor suppose any time had elapsed, but as if nothing had happened continue the sentence in the midst of which he was interrupted.

592. 3d. The sensation produced, is always, so far as we can learn, in accordance with the state of the brain and nervous system. If the nerve of a tooth be touched, we can anticipate what sensation will be produced. If the eye be inflamed in certain parts, we can anticipate that a little light will produce a sensation of dazzling, and the skilful physician, by taking into consideration the condition of his patient's nervous system, can usually judge what kind and degree of sensation he feels. If the eye, nerve, and brain, be perfectly healthy, we know what colors will produce agreeable sensations. The world over, a combination of blue and orange colors are pleasing, so are red and green, or any colors a mixture of which will produce white light; blue and red, red and yellow, are disagreeable (Fig. 85).*

Fig. 85.

* Those colors which mingled produce white, are called harmonious, or complimentary when spoken of in reference to each other. The combinations not producing white, are called disharmonious. In Fig. 85, the simple colors are placed at the angles of a triangle, in a circle. They are of course harmonious and complimentary of each other. At intermediate points of the circle and at extremities of diameters are placed colors formed of those at the nearest corners of the triangle, and it will be seen that colors at the extremities of diameters are harmonious or complimentary; so will be all shades of the same colors which would be formed at the extremities of any diameters. In consideration of this Muller remarks, "Women of good taste, when they have a single predominant color in their dress, select a dull one; or if they wear pure colors, combine those which harmonize from being complimentary of each

593. 4th. The character of the sensation changes too easily for us to suppose that it depends on the mind. Various articles of food produce a high relish for other articles; a "taste" is soon acquired for food at first "very disagrceable." A glass of wine will often make a person pleased with the effect of objects otherwise disliked; a thousand other instances could be suggested.

594. It would seem, therefore, as the tendency of objects to produce effects is uniform and invariable, and on the other side, so to speak, of the nervous system, the character cr nature of the mind uniform and invariable, that all variation in sensations is to be attributed to the variable character or

other; for instance, they wear a red shawl over a green dress, combine lilac with yellow, or blue with orange. How beautiful and pleasing to the eye, is the combination of a golden orange color with blue; for instance, of an orange fringe with a blue drapery, while the dress of a female in which pure yellow were combined with red, or yellow with blue, or blue with red, would by every person be regarded as hideous and out of taste. Such striking combinations of disharmonic colors are chosen only for national signs and the dress of soldiers. The disharmony between two colors may however be removed by the interposition of a third color which is the harmonic of one of them, and is indifferent in relation to the other, as in red, green and yellow; blue, orange and red, &c. Painters, either intentionally or without being aware of it, make constant application of these physiological principles; and the pleasing effect of colors in a picture, depends on the skilful combination of harmonic colors. By employing principally the dull gray colors the danger of disharmonics is avoided, but the whole charm arising from the harmonic combination of colors is renounced." Thus persons may dress or furnish their houses in a pleasing manner by applying physiological principles; but in dress, what has been said upon the reflection of light, must be remembered; viz., that light from the dress passes to the complexion and is reflected, mingled with any other light reflected from the facc. Some articles of dress would improve the complexion, therefore, and if at the same time harmonious in colors, very pleasing sensations will be produced. But the greatest care will be requisite in arranging bright or pure colors either by natural taste, or by rule; hence it is safest for most persons to be sure and never offend good taste, but to wear unobtrusive colors and small figures and furnish their apartments in a similar manner. Yet by study a person can improve upon this plan and secure much admiration.*

* It is worthy of admiration that in all the natural objects, among millions of flowers of every hue and tint of color, in the "ever changing glories of the sky," colors in near relation to each other are always harmonious. Hence why flowers and imitations of natural flowers are ever so attractive and adorning. and it is a little singular that "flower makers" should combine flowers and colors as nature never does, taking pains to avoid a perfect model, and always with a bad effect.

state of the organs of sense, nerves and brain; to wit, as these parts are, so are the sensations.

595. The duty of the mind seems therefore, in respect to sensations, to be: to perceive them, to judge where they have been produced, and to be pleased with them if their causes are productive of no harm to the body, and to be repugnant towards all which are produced by causes acting harmfully, to remember them, to compare those remembered with each other and with new ones, and thus acquire knowledge of the objects which surround us and of the states of the internal parts of the body.

596. *Perceiving sensations.* Nothing is known of the manner in which sensations are perceived, in other words, how the brain acts upon the mind. It may be curious to ask if the mind occupy much space in the brain, or if all the nerves of sensation terminate almost at the same point? No reply can be given. The only light that is shed upon the subject, is obtained from this; that nerves from different organs of sense, do not seem to pass towards the same identical point of the brain.* The nerve of sight does not follow the course of the olfactory nerve, though they are very near each other at one point. The nerve of sight takes a very circuitous route to where it appears to terminate, as if there were a necessity in the fulfilment of its duties that it should visit certain parts of the brain. But where it appears to terminate may not be its stopping place. Much might be written therefore, and yet be but little, as it would be so unsatisfactory.

597. The mind has control over its powers of perceiving sensations. As the expression is, "it can give attention" to sensations, or divert its attention. How this is done is not known. Whether it removes itself from the part of the brain through which sensations are produced,

* If metaphysicians find any fault (which they reasonably may) with language used in a physiological discussion of mental operations, they are desired to remember, that it is the wish not to be considered as entering on their department of learning at all. What is said is merely in connection with physiology, and to convey clear ideas on that subject; metaphysical interpretation is not, therefore, ever to be given to terms used, but a physiological sense merely. Any point in metaphysics will be instantly yielded, as belonging to a subject upon which men more learned in that department, are better qualified to express an opinion.

or whether it stills the action of the brain, is all unknown. The exercise of this power of attention affects the intensity of sensations in a remarkable degree. If attention be given to the sensations produced by food, they will be very much heightened thereby, as hereafter seen; facilitating the process of digestion, if the food be wholesome. But if the attention of the mind be absorbed with business etc., food will be swallowed without relish, and very soon such a course will be followed by dyspepsy. A person may ride through the pleasantest section of country and appreciate none of its charms, because his mind gives no attention to causes of sight and sound. To one person there are "sermons in stones, books in brooks;" another person looks upon the beautiful flower and no admiration is awakened, for his mind heeds not the sensations it was made to produce.

598. The attention of the mind being engrossed with the importance of staying the ravages of fire, or with the strife of battle, a person feels not a wound, or the most exhausting fatigue. On the other hand, the attention of the mind will cause the slightest sensations to appear insupportable. He who gives attention to every ache and ail, will soon appear to himself to be the most afflicted of the human family, and indeed, he will suffer more than those who are acted upon by the most powerful causes of painful sensations. To nurse every pain of a child, caused by cut or bruise, etc., is to make it suffer on the slightest occasion; while to call off its attention and make it "forget" the hurt, is to teach it to be manly, and use the true means of relieving unavoidable misfortunes of their intensity.

599. *Judgment of where the sensations have been produced.* How this is arrived at by the mind is not, of course, known. Some sensations are general, but most seem to be produced at the commencement of the nerve through which they have been produced. The mind is liable, therefore, to many errors in respect to the state of the body. Sometimes diseases seem to be at the commencement of nerves, not, as far as can be judged, being at all concerned in the production of the sensation. Some suppose the state of nerve necessary to produce a sensation, is caused in the nerve of the unaffected part by the nerve of the affected part, which passes near to it, but this is uncertain. Disease, and various causes, by acting on the nerve in some part of its course, as has been shown, would lead the mind astray in the formation of its opinion. The most tormenting itchings, and terrible pains, are thus very frequently thought to be produced by the state of a part which, in fact, is quite healthy, and many applications will be made without avail. The power

of causes producing sensation, is judged by the intensity of sensation; but this depends not only on a cause, but on the state of the nervous system through which the cause acts. A slight cause, therefore, in one person produces acute pain, and from similar pain in another, it might be argued that the cause was slight, when, in fact, it was not so. In the first case nothing being done, the person would recover perhaps; in the last he would die. Thus is evidently seen the importance of educated, experienced skill.

600. In a similar manner is the mind liable to misjudge of causes surrounding us. There being so many causes beside surrounding objects which modify the sensations upon which the mind bases its judgment; for instance, a rush of blood through or across inflamed nerves causes sensations which make the mind believe that a carriage is rumbling, a bell ringing, etc. So an "excited" state of the nervous system will cause sensations of sight entirely unworthy of confidence.

601. *Production of pleasing and disagreeable sensations.* The mind is so made as to be usually pleased with the sensations caused by harmless objects or a healthy state of the system, and disagreeably affected by those of harmful objects or states of the system. But there are exceptions: the exhilarating effects of alcoholics, and the "reconciling" effects of tobacco, are seductive to man, but refused by animals. Why this is so is evident, if the destiny of man be considered. He has not been designed to occupy so narrow a portion of the world as any other species of animal. The whole earth is *his* inheritance; *his* hand combines the weapons of every other animal; *his reason* more than compensates for the instinct of the geometrical bee or the architectural beaver, and the range of *his tastes* includes every variety of pleasure that air, earth, and water are capable of producing through nerves and brain. To think, however, is the chief duty of man, as well as the source of his highest pleasure. To preserve himself from danger, in many cases, nature therefore has made it necessary for him to acquire knowledge and apply it, of which necessity she has deprived animals, supplanting it by unmeriting instinct, which always compels the animal to act for its good; but man can use his powers or not, and for his good or harm, as he chooses. His instincts warn him, therefore, only of dangers of which the application of his cultivated mind could not warn him, and this they do most perfectly.

602. *Memory of sensations.* This is an exceedingly important duty of the mind. It would seem that the mind performs this act unassisted by the brain, since, as will hereafter be shown, the brain is continually

undergoing changes in all its parts, so that no portion of it remains much length of time in one position. Some suppose, that when the mind would remember a sensation, it so acts on the brain as to produce a similar state as that which previously existed when the desirable sensation was perceived, and that when the state of the brain cannot thus be reproduced by the mind, the sensation cannot be recalled. Others suppose that an effect once made upon the mind by the brain, can be recalled by the mind without the assistance of the brain. It matters not—sensations are remembered, and by that means,

603. *Sensations can be compared.* By this important process the mind stores itself with useful ideas, and knows the cause of sensations. For instance, if a pound weight be taken in the hand, and the sensation be remembered, the next time a weight be taken in the hand that upon comparison produces a similar sensation, it is considered to weigh a pound. If sugar has caused its sensation, which is remembered, sugar will be thought the cause of any similar sensation, and so of other things, and also of the internal states of the system; for instance, if a person have suffered any kind of pain in any part of the body, and feels the like again, the cause having been learned or told him in the first instance, he will think it exists again. Thus from the kind of pain and location of it, the physician judges very much in respect to disease.

604. But the mind is very liable to fall into errors. Causes producing sensations are so numerous, that it requires a very long time to experience in regard to them all. Many produce similar sensations, and mistakes may be made, like that of the negroes of the West Indies employed to unload the first cargo of ice ever carried to those places. They threw down the first lumps, declaring they were burned. Such sensations they had never felt, except produced by heat. They knew not that intense cold produces similar sensations. Again, objects with which we are acquainted produce sensations so similar, that much skill and experience is required that an accurate comparison may be made. Again, the sensations produced by a cause, and the comparisons made, depend much upon what causes have preceded. The taste is altered by various articles, as already shown. If the eye have been fixed on a bright red object, and then turned to a white one, it will appear green; for the effect of the red has so fatigued the nerves, if the expression may be used, that the red light from the white object produces no effect, and the blue and yellow acting without the red, produce the effect of green. If heavy weights have been held, a pound weight will seem very light. So also different states of the same or different parts of the body produce similar

sensations; and also as the sensations produced by surrounding objects and the states of the body depend on the condition of the nervous system, it is evident that great experience is necessary, as well as a very retentive memory of sensations, and an accurate judgment to compare, that the mind may arrive at correct conclusions in respect to the causes producing the sensations it perceives. The mind obtains assistance also in determining the character of objects, by causing any object about which there is doubt, to produce more than one kind of sensation; for if different objects produce similar sensations of one kind, they will produce different sensations of some kind. It is of much importance, therefore, to know what similar and what dissimilar sensations different objects, especially different diseases, produce. For if similar sensations of two or three different kinds are produced, we are apt too hastily to think that the causes are similar. A dropsy, for instance, may exist, and one inexperienced would, perhaps, think there is one cause and one cure; but greater skill would teach that dropsy is an effect produced by many different causes, and other signs would be looked for, till by them the common cause of them and the dropsy would be found.*

Section 7.—*Concluding Remarks on the Organs of Sensation.*

605. So little is known of the precise manner in which any organ of sensation performs its duty, that it is impossible to make any very particular inferences in respect to the particular mode of managing the various parts of them. From the powerful sensations produced by the minute particles of odoriferous substances, too subtle to be appreciated by other senses than that of smell; from the ready action of the feeblest causes of sound, which can only be produced by a change in the state of the nerve; from the powerful action of only a single grain of morphine or a drop of prussic acid, which will lock the nervous system in the soundest slumbers—many times the sleep of death—it would be expected that,

606. What would usually be called insignificant causes will be sufficient to produce disease of the nervous system,

* Here the folly is seen of "doctoring" signs or symptoms, or administering remedies without great knowledge, the result of study and experience, and especially without a knowledge of the *cause* of the symptoms exhibited.

causing dreadful suffering and most tedious in its duration; that the suffering might commence suddenly and terminate as quickly; that as the slightest causes may bring it on, so the slightest causes may remove it; that, if the state of the nervous system be changed by any cause, there will be a change in the sensations produced by the disease, perhaps for the better, perhaps for the worse; and from what has heretofore been said, it would be expected that sometimes one thing, sometimes another, would change the state of the nerve, by which painful sensations are caused. *It is also in accordance with common sense, that while an endeavor is made to change the state of the nerve causing pain,* ALL CAUSES TENDING TO PRODUCE SUCH A STATE MUST BE SEDULOUSLY AVOIDED.

For instance, it is useless to call on the doctor to cure neuralgia, while a person is continually exposed to take cold, etc.

607. It is also found that pain, by the effect produced on the good nature of a person, and by the bad effect produced upon the nervous system, is one of the most powerful causes for deranging the action of all parts of the body, and wearing out life.

608. If any state of the nerves producing pain can be changed without doing decided injury, it should be done; not more for the purpose of preventing pain, than for preventing the farther progress of disease.

The usefulness of this principle is shown by the great reputation which some physicians have acquired almost solely by the use of opium and its compounds, and of other narcotics (inducing sleep). These articles are indeed great blessings, if used judiciously, but productive of eqnal harm if improperly used.

609. If the skin be exposed to the cold, and the blood thus driven from the nerves in the skin, the sensations produced through the skin are correspondingly blunted. Thus, if the skin may be taken as a criterion, and also, from the fact that the wants of all parts of the body are supplied from the blood, it may be inferred,

610. A free supply of pure blood is requisite that the organs of sensation may fulfil their duties.

This is obtained by the use of proper food, drink, air, and all the means hereafter shown to produce pure blood; and by muscular exercise, and rubbing the system, which sends the blood more rapidly through every part of the body, by proper clothes, etc. And if the exercise of the eye may be taken as a criterion,

611. Exercise of the organs of sensation causes a brisker flow of blood through them.

The eyes of the student frequently afford evidence that exercise increases the quantity of blood passing through an organ of sensation. Some suppose that exercise is useful only by causing the mind to give stricter attention to the sensations produced; but while it may be allowed that attention is all that is necessary in many instances, yet it is also certain that the sailor, by the exercise of his eye, not only concentrates his attention, but perfects his power of adapting the eye for long sights; while by exercise, the watchmaker gains the power of adapting the eye to near objects.*

612. Proper exercise of the organs of sensation improves their physical condition and powers.

In what way is not certain, as it is not known which part is improved when vivid sensations are produced. Without doubt the power of giving attention is increased, and considering things hereafter to be shown, it is probable that the constituents of the organs of sensation undergo changes in the fulfilment of their duty, which changes are made more rapid by exercise, causing the increased flow of blood necessary to effect the change,† and as the parts undergo their changes, they become adapted

* When the eye turns in (is cross-eyed) from want of power of adaptation, which is a frequent case, it can be trained to adapt itself by having the other eye covered for a short time together, but very frequently, and then using the ill adapted eye in looking at distant or near objects, as the case may require. In some cases the eyes alternately turn in, because one can adapt itself to near, while the other can only adapt itself to distant objects. In this case the eyes must be alternately covered and exercised in those ways in which they ordinarily fail. Nothing of this kind must be expected to succeed except with months of practice, resolutely persevered in every day.

† When an eye is found to be weak, on which account it turns, it may many times be strengthened by a proper course of exercise, the other eye being covered, but great care must be taken not to use the feeble eye too long at one time.

to the requirements made upon them, as it is a universal rule of nature to adapt a part as far as possible to fulfil the duty required of it.

613. Whatever may be the particular cause, there is no doubt that exercise renders the sense of touch more delicate, the sense of taste more refined, the sense of smell more acute, the sense of hearing more exquisite, the sense of sight more perfect, and the muscular sense more accurate.

614. Over exercise enfeebles the organs of sensation.

There is, however, little danger of over-exercise of any organs except those of sight. Inhalation of intensely acting odors, such as smelling-salts, etc., have in some cases much injured the sense of smell, while strong spices, etc., act as injuriously upon the sense of taste.

615. The remedy for over-exercise is rest, entire, and prolonged.*

616. Thus is concluded the chapter on sensations, the contents of which, may not have been easy to understand without some study and thought; but the principles herein developed it is hoped will induce the reader to cultivate to the full, his powers of rationally enjoying this world, and he will exclaim with Campbell the poet in a letter to a friend, "What adorable beauties of God's and nature's bounties we live in without knowing."

* If an eye be weak, and turn because it requires rest, this should be allowed by covering it for a long while, after which it is to be gradually strengthened by exercise.

CHAPTER III.

ORGANS WITH WHICH TO THINK.

General Observations.

617. 1st. Facts already advanced prove that from the brain influences are exerted upon all parts of the body, and that from all parts of the body influences are exerted through the brain upon the mind, producing sensations. These things prove that the mind is enthroned in the brain as a political capital, from which centre, through the nerves as avenues of communication, it can issue its mandates to every part of its corporeal kingdom, and from every part of it receive by nerves, continual reports of its condition, welfare, and wants. Hence it would be necessary that the same centre, the brain, should furnish the mind with the apparatus necessary for thinking, if any be required.

618. 2d. When engaged in thinking a person experiences a sensation distinct and perfect as any produced through the ear or eye ; the location at which it is produced, appears as decided as in case of sensations of sound, and more so than in case of the general sensations of thirst, hunger, &c. Intense thought will call attention to the front part of the head, as if the acting cause of thought were there. If the hand be applied to the forehead it will feel hot, and the application of a cold cloth will give immediate relief; the thoughts, from being confused and vexing will become clear and pleasure-giving. When a new idea has been gained not only is there a feeling that knowledge has been acquired, and pleasure thereat, but also a sensation of a more physical character, so to speak, in a certain sense like the sensations produced through the ear, eye, &c. So when memory is exercised or judgment formed, a sensation is felt, feeble or intense, of a pleasurable or unpleasant character, in the same manner as sensations treated upon in the previous chapter. A sensation of this character is called consciousness (physiologically speaking). Another reason why consciousness may be considered as a

sensation produced by the action of the brain upon the mind is, that consciousness ceases the instant the action of the brain ceases, as found in cases where the brain is or can be pressed, by which unconsciousness even of passing time is produced. Fits of apoplexy, "fainting away," and even profound sleep, produce a similar unconsciousness even of existence, for the brain cannot then produce sensations.

619. 3d. If the brain be slightly inflamed, not only are sensations of sound, sight, &c., readily produced, but the thoughts spring up to the mind with facility and succeed each other in a very rapid manner, while if the state of the brain be such that sensations of feeling, &c., are produced with difficulty, the intensity of a person's thoughts, as well as their activity, is slight; thus showing that the character of a person's thinking powers can be determined, in a general manner at least, by the condition of the brain.

620. 4th. It has been often noticed by the student, that the head becomes hot and the feet cold when engaged in intense study. Nothing is more common than to hear professional and indoor business men complain of "cold feet," no matter how warm the apartment is kept. Why is this, except that the activity of the brain necessary when thinking is done, requires an increased supply of blood?

621. 5th. Two persons may hear at the same time, of the death of some dear friend of one of them; the voice of him who tells the tidings falls on the ear of each alike, the same effect is produced on the nerves of hearing in each case, and they produce the same effect on the brain, and the physical brain produces the same effect on the mind. But the eyes of one remain dry, while tears gush from those of the other. Why the difference, except that the emotions of one mind act upon the brain with which it is connected and through nerves upon the tear apparatus? The cheeks redden and the limbs quiver with anger, rage will even gnash the teeth, while smiles are indicative of gentle feelings, the downcast eyes of reserve, nor can the beautiful blush of modesty be ever seen on the face where haughtiness rules the mind. But when by disease or accident the nerves connecting between the brain and body are unfitted for use, an unmeaning stolidity stares from the expressionless face.

622. 6th. In the morning, the heated brain of the evening previous has become cool, and after a bath of cold water upon the head, feels ready for action, and in a corresponding manner the composed thoughts of the evening become regular, and thinking becomes a pleasure; the business man gives his attention to his business, the farmer to his labors, the student to his studies, and all with delight. So during the day, if

the mind become confused, muscular exercise, a walk, a ride, or aught else which gives repose to the tasked brain, will produce in a short time regular action of the mind.

623. 7th. There is a large amount of nervous substance forming a great part of the brain for which there seems to be no use, except the mind make use of it in its thinking operations. Other arguments might be advanced, but these are sufficient to prove, it would seem, that

624. There are two requirements for thinking: 1st, a mind, the efficient cause of thinking; 2d, a brain, with which to think.

Section 1.—*The Brain.*

625. How the mind acts upon the brain, or the brain upon the mind, in the production of thought, is not known, and most of the curious questions which might be asked in reference to the matters under consideration can only be answered by supposition, supported sometimes by very good arguments, but usually only by probabilities. We may first, therefore, notice facts, and secondly, follow them with inferences.

626. *a.* The brain is composed of many parts, differing in color, structure, composition, form, position, relation, and mode of connection with other parts, and in respect to the quantity of blood received. The difference in any of these respects is not, however, very great.

b. The mind, through the brain, has different duties to perform. It must receive sensations, it must exert influences, it must have thoughts, emotions, &c.

c. When one kind of intellectual pursuit has caused fatigue, attention can be given to another with nearly or quite the same efficiency as if no fatigue had been felt.

627. From these facts it is inferred, that different parts of the brain are used by the mind in fulfilling its various duties. To this it may be objected, that disease of any part does not always produce like results. Sometimes no appreciable results are produced by extensive disease. Sir Charles Bell states that he has seen every part of the brain except

the gray part extensively diseased, and yet the duties of the mind well performed; while others have seen the gray part as much affected, without producing any apparent influence on the accomplishment of the mental duties.* Large portions of certain parts of the brain may be lost, by accident, without producing any apparent effect on the mental operations. Such facts are against almost any inference that may be made in respect to the action of the mind and brain upon each other.†

* By some, it has not only been inferred that the brain consists of parts, but that the situation of these parts has been determined; for instance, that the front parts of the brain are the organs used in the intellectual operations of the mind. These grand divisions have again been divided, by some, into a small number, by others, into a multitude of parts. One step further has been taken, and it has been inferred by some, that the larger these parts or organs, used by the mind, the more efficiently, other things being equal, can its duties be performed. Still another step being made, it has been inferred that the size of these parts or organs could be determined by examining the head externally, and thereby the capacities of a person determined, other things being equal. Whether this be so, any person, it would seem, could satisfy himself by making a few experimental examinations, and especially by examining and comparing the skulls of different skeletons, and noticing if there be such uniformity in their thickness in corresponding parts as to warrant the inference that the size of the different parts of the brain could be determined by an examination of the head externally, even if it were allowed that the brain was composed of a congeries of organs, all coming to the surface of the brain, and that the larger any part of the brain, other things being equal, the more effectual the operations of the mind through it. He might then examine and compare brains of different heads, to learn if the apparent enlargement of any part of the brain might not be produced by the enlargement of some other part crowding upon it, so to speak, and causing it to be prominent; for there will be found many parts in the brain which do not come to the surface, but are buried deeply below the parts forming the surface. He may notice, likewise, that many parts of the brain having the same appearance as those directly within the skull, are found at the surface of the brain, where the falx (Fig. 47) separates one half the brain from the other. He might ask if these parts do not perform important duties for the mind, and if there be any way of determining what, or how much effect, the action or size of those parts of the brain would have upon the character and capacities of a person. Many similar questions he might ask, and settle in his own mind, it would seem, by a slight examination. Assertions, no matter by whom, either upon one side or the other, would of course be of no avail; the matter is therefore left with these hints of some of the points to which a person might give his attention, before making a decision.

† One case is at present in mind, where a boy from the front part of the brain lost more than half a teacupful of substance. In a few months he was well and attended school, making as rapid intellectual progress as ever, and he was always remarkable for proficiency in his studies.

628. *a.* There is a very large quantity of blood passing to the head; in proportion to its size, from five to ten times as much as passes to any other part of the body, except the kidneys.

b. The quantity, as already stated, increases with the activity of thought; and vice versa, the activity of thought is increased by an increase of the rapidity of the circulation.

c. The blood which passes to the head is of one quality, and goes through one set of vessels; the blood which passes from the head, is the same in quantity but differs in quality, and comes through another set of vessels: that is, the blood undergoes a change as it is passing through the brain.

It would seem to be correctly inferred, therefore, that the brain had undergone changes corresponding to the changes in the blood; and that as the circulation of the blood corresponds with the activity of thought, so the *activity of thought must correspond with the changes which take place in the brain.*

629. *a.* If the blood be ever so large in quantity in the brain, the thoughts are not active, if the blood be stagnant—as in case of apoplexy—in which many times or always, the bloodvessels of the head are crowded with blood, but the mind is inactive.

b. If the blood have not been properly acted upon in the lungs, it is found that though it flows through the brain in sufficient quantities, a person becomes insensible.

The inference is, therefore, that it is not the *quantity* of blood which the brain receives, merely; but the quantity and *quality* of the blood which prevents or facilitates the changes in the brain necessary to the production of thought.

630. *a.* For the fulfilment of their duties in a perfect manner, all parts of the body depend upon the blood.

b. As in case of the muscles, all parts are found to require more blood when active, than when in a state of repose.

c. There is only a given amount of blood in the body at any one time; and if this be in one part, it cannot be in another at the same time.

It is, therefore, inferred that when the blood is elsewhere than in the brain, the thoughts cannot be active in the highest degree; and vice versa, when the thoughts are active and producing rapid changes in the brain, blood in large quantity is then required, and it cannot at the same time be allowed to circulate rapidly in other parts: hence the feet become cold, the food in the stomach is not digested, and muscular exercise cannot be taken with profit. Hence severe study should never be allowed just before or after a repast of food, or during the active performance of duty by any part of the body beside the brain. While, on the other hand, a person should not direct the blood to any other part of the body when the brain requires it during the production of thought.

631. Only a small portion of the blood is adapted to take part in the changes produced in the brain during mental operations.

It would be inferred from this, that the production of thought would be limited, not only by the quantity of blood the brain received, but by the quality of it; and that whatever would contribute to improve the quality of the blood, would equally contribute to facilitate the production of thought: hence, that pure air and a healthy condition of the lungs would be necessary for the perfect accomplishment of mental duties; and not less necessary will be a supply and healthy digestion of wholesome food.

632. *a*. Proper exercise of the muscles, has been found to have a favorable effect upon the thinking powers.

b. It has been already seen that exercise of the muscles furnishes to the blood a supply of substance no longer of use to the muscle, but indeed a detriment if allowed to remain in the muscle.

It might be inferred, that among other ways in which exercise of the muscles and other parts benefited the brain, one was that of supplying the blood with substances, which though no longer useful to the muscle, might serve a purpose in effecting the important changes which thinking produces in the brain; and so on the other hand, may the results of the changes in the brain assist in perfecting the muscles.

633. *a.* Time is necessarily required in producing the changes which take place in the brain during thinking.

b. After intense thinking for a time, the thoughts become confused; but after a repose, they are again rapidly produced in a regular manner.

The inference is, that the power of producing thought is limited not only by the quantity and quality of the blood, but by the length of time required to re-perfect the brain; and that the best time for thought and study will be in the early part of the day, after the repose of the night—and after a little exercise has been taken to circulate the blood through the entire system, in some parts of which it may have become stagnant, so to speak, during the night.

634. *a.* The powers of different persons are very different in respect to the offices of the lungs, the digestive organs, the circulation, the blood, &c.

b. In the same person the health affects the lungs, the stomach, &c., in the performance of their duties, and intense thinking soon exhausts the powers of the brain.

c. If the body be rapidly growing, it is necessary that the blood should circulate very freely through the growing parts especially, as some of the ingredients required by the growing parts exist in the blood in only very small quantities; the blood must not, therefore, be monopolized by the brain, and thinking will soon exhaust it.

It is to be inferred, therefore, that one person will require more frequent and longer repose than another; that in ill health longer and more frequent repose will be required than in health, and that in childhood, very frequent intervals of repose will be required, and *it is also to be inferred, that compelling active thought and intense thinking for a long while, in case of a child, will sacrifice the welfare of the various parts of the body, and undermine those organs, the vigorous action of which is necessary to sustain the efforts of the mind in mature years.**

* It unfortunately happens that those children with a brain altogether too active for their age, are urged many times to study instead of being encouraged in those exercises which would turn the flow of blood from

635. *a.* Intense thought for a long time is attended with a fulness and heat of the head, from which the application of cold gives relief.

b. In such cases the slightest exposures sometimes bring on the most alarming diseases.

From this it is to be inferred, that a very active circulation of blood through the brain, at last produces a measure of stagnation of the blood, or a distended state of the bloodvessels of the head, which prevents the proper changes of the brain, and of course, the production of regular thought, and brings the brain to the brink of disease; and that to prevent this, it is very important not only that intervals of repose be given to the brain, in which to recover its perfection; but also, *that the injurious effects of too active circulation of blood through the brain be prevented by vigorous exercise of other parts of the body, especially the* MUSCLES; for, as during their exercise they require the blood in large quantities, it will be drawn off from the brain. Thus on the one hand, the heat of the head will be lowered, and that of the other parts of the body raised; and as the student is so constantly on the verge of too active circulation through the head, he must avoid every other cause besides study which tends to increase the flow of blood through the head, whether it be in the form of a glass of wine, an overloaded stomach, or a "common cold." Indeed, over the desk of every student, and every business man, it should be inscribed in golden letters, "KEEP THE FEET WARM BY EXERCISE AND THE HEAD COOL BY TEMPERANCE." It is also to be inferred, that the child should have frequent moments of relaxation devoted to exercise of its lungs, its muscles, etc.

636. As the muscles when first used, or unfrequently used, do not receive the blood in proper quantity, but as by exercise, increased from time to time, the vessels become larger, and the flow of blood through them greater, and the muscles capable of perfecting themselves, in accordance with what is required of them:—so, also, does the brain become capable of accomplishing more and more, by grad·

the over active brain to the undeveloped parts of the body, which being strengthened, will labor in the service of the brain with great effect at the period of maturity.

ually increased exercise, while every attempt to overdo, exhausts and diminishes the powers of the brain.

Hence children should not be overtasked with studies, for as the growth of other parts of the body is stunted by too severe labor, so is the brain prevented from developing its powers by too assiduous mental application in early life; and those who enter upon a course of study, must accustom the brain to its duties by slow degrees.

637. Mental exercise is attended by increased circulation of the blood, which does not at once subside, as is seen in the continued excitement once produced by any cause. It is, however, reduced by exercise of the muscles, &c., by cold applications to the head, and warm applications to the feet.

It is hence to be inferred, that study should not be engaged in for a time previous to the hour of retiring to sleep, as quiet of the brain is desirable in order to secure quiet of the mind. Also, that gentle muscular exercise, warming the feet, rubbing the skin briskly, and a cool application to the head, will subdue the circulation of blood through the brain. To do some or all these things just before retiring, is desirable on the part of all, but especially should they be done by any person subject to apoplexy, or fits of any kind, dreams, disturbed sleep, or any of the causes of wakefulness.

638. *a.* When a man becomes insensible from intoxication, he is brought to his senses by cold applications to his head, and heat applied to his feet and hands.

b. When a person has taken opium and becomes stupid, or sleepy, he is roused by rubbing, by heat applied to his hands and feet, and by cold applied to his head.

c. When the physician is called to a man in a fit of apoplexy, he rubs him, applies heat to his feet and hands, and perhaps draws blood.

From these things it is safe to infer, that when a person is stupid or insensible from any cause of disease or accident, it is proper to use those means which will draw the blood from the brain into other parts of the body, viz., keep the head cool, rub the skin, and make warm applications to the extremities, and if the case be severe, let blood flow *out* of

the system altogether. Especially it is important when a person has met with any accident to the head, such as a severe blow, though the skull has not been fractured, that the head be kept cool, and the brain kept from exercise that shall tend to draw the blood to the head, and the skin generally, but the feet in particular, from exposure to the cold.*

639. We may now consider the sensations produced by those parts of the brain employed in thinking. They are of three kinds. *a*. When the mind is exercised according to the laws already inferred, the most satisfactory and delightful sensations are experienced. To think, and acquire knowledge is the sphere, the duty of man, to think and acquire knowledge is also his highest pleasure.

We are therefore to infer, that when changes of the brain take place in accordance with its best welfare, such a state is produced in the brain as acting on the mind causes agreeable sensations, and a desire to do that which shall be productive of such pleasurable results.

640. *b*. When the mind is over-tasked, mental fatigue is produced, and an intense desire for repose, until at last, all effort to continue the process of thinking is overcome, and "tired nature's sweet restorer, balmy sleep," comes to the relief of body and mind.

Hence it may be inferred, that when the changes of the brain have been carried to that degree which is injurious, they produce a state which, acting on the mind, causes disagreeable sensations, which at last overcome the exercise of the most determined will, thus acting as their own regulator.

641. *c*. When the mind is not engaged in thinking, it soon feels an uneasiness, an unsatisfied want, a desire to perceive sensations, which must be gratified, for it is the nature of

* A case occurred last summer, in illustration. A young man was kicked on the head by a horse. He was doing well; the physician ordered his head kept cool by cold cloths, and advised him not to leave his room; but feeling well one pleasant afternoon, he laid off the cloths, went into a back kitchen with earthen floor, and sat with his bare feet upon the ground and his head near a heated cooking-stove, for some time. It was the cause of his death.

man to desire to perceive new sensations. As the old proverb is, "Those who have nothing to do, will do mischief." The plaything received by the child is turned on every side and torn in pieces that it may produce new sensations, and when it knows all it can in regard to the thing, it is cast aside and a new article demanded. This desire is usually called a natural curiosity; but

It may be inferred that the brain is so constituted as to produce sensations of uneasiness when those changes have not taken place in the brain which are for the good of man, by the cultivation of his mind attendant upon a certain action and changes of the brain.

642. The man therefore who gains the idea that acquiring knowledge is not for him, does not understand his nature, the constitution of his mind and brain; he talks of the weather, he goes in and comes out, rises up and sits down, yokes himself reluctantly to labor, and wonders why he was made a slave, to work, to drudge, like the horse that toils by his side. He is mistaken. He was not made so to be. His horse is thoughtless, and while he is thoughtless, how can he claim more than his fellow animal? But let him awake to the importance of his estate, enter the walks of useful knowledge, exercise his mind and brain gradually till both mutually assisting to develop each other, reach maturity, and he will find there are no "common men" but those who satisfy themselves with the mere physical enjoyments of animals, which perhaps even the oyster may share with them—but that whoever makes study his diversion and the pursuit of wisdom his satisfaction, according to the intentions of the Creator, will have the noblest spirits of the past and present ages for his intimate friends, and raise himself to a point of eminence from which he can "look up" to no being but God.

643. Whoever likewise, pictured the temple of science on a steep and stony hill, up which a long life the student

must drag his weary steps to reach the summit, and then be satisfied with—what?—a wreath bestowed upon his ambition! knew not the nature of man nor how to open before him the gates to the smooth and sunny paths of science, where flowers and fruits abound on every hand, not as delicious near the entrance, as farther on, for every step proves more seductive, but such as are well adapted to the relish of the mind commencing its progress. Commend me to the teacher whose scholars will cry if kept at home, and save my children from one who thinks he must drag the unwilling votary to bend in worship before the shrine he has wrongly learned to hate. Disgust of thinking will be produced when the mind is compelled to apply itself against every law of nature, when the body, the brain of which the mind is to think with, is so placed that it must constantly warn by aches and weariness, of the harm it is suffering, when the buoyancy and playfulness of youth are denied their action, and after all, not that the mind may be caused to think, but made to con something, to "learn by heart" what is not understood, in short, to encounter all the drudgery, but not arrive at the pleasure of thinking.

644. Every thing about the student should, on the other hand, be pleasant, and every agreeable sensation of sight, sound, &c., should in its place, for it has a place, be made to add to the delight of fulfilling this important duty of man—cultivating a desire to obtain knowledge, cultivating a pleasure in the exercise of the mind and brain. School houses should be in pleasant situations, should be comfortably and attractively furnished, and abundant opportunity allowed for physical recreation, and the grand principle, acted upon, that *The human mind can better be led than driven to the acquirement of knowledge*, or another still more excellent but embracing the same idea: "To please is the first step towards instructing."

645. In the attempts to reform society, it is too frequently forgotten that the cause of vice, many times, is want of occupation. The mind will have sensations produced, and cannot bear the ennui of "nothing to do." Cultivate, in younger or older, the desire to acquire knowledge, the power and pleasure of thinking, and the mind will always find something wherewith to occupy itself. The world around upon the murkiest day, or the wonders of his own body, will afford subjects to the thinking man, such that he will never be ready for the setting sun. But if the mind be not in the habit of thinking, the instant the young man is free from his business or his labors, he is solicited to the haunts of dissipation, where the delirium of strong drinks and the accompanying revelry may make the mind forget its self-weariness—for the worst of burdens is an unoccupied mind. Hence it is better for the public to educate the ignorant, than to support them as paupers or criminals—for the ignorant are almost sure to become either paupers through dissipation, or criminals, by putting their hand to mischief rather than want something to "drive dull care away."

646. We may now consider the emotions:

a. The language of the emotions is uniform—the tearful eye is the language of pity, &c.

b. The emotions exhibit themselves by increasing or diminishing the health of the system. Dr. Beaumont testifies, that "anger would check the digestive process sometimes for an hour;" and melancholy feelings are universally known to depress the action of all parts of the body, while lively emotions invigorate. Says some old philosopher—"Every hearty laugh draws a nail from a person's coffin, while every sigh drives two in." Indeed it will be found, that all those emotions which tend to render a person a good member of society, tend to improve health and beauty, and to lengthen life;

while all those which tend to promote selfishness, such as anger, revenge, &c., depress health and shorten life.

It may be inferred that the brain is active when the emotions are active, and in a degree corresponding with them, and that man is intended to live in society, and that the true refinements of civilized, educated society, are most conducive to health and longevity.

647. Uneducated persons exhibit emotions of every kind in the highest degree.

It is to be inferred, that that condition of mind and brain most proper for developing thought, is not necessary for the exhibition of emotions.

648. *a*. When the exhilarating or exciting passions are exhibited, there is evidence of a very rapid circulation of blood through the head, but when the depressing emotions are exhibited it is quite the reverse.

b. After the exciting passions have continued for a time, they produce exhaustion of the most decided character.

From these things it is inferred, that as in case of thinking, so in the exercise of the emotions, there are changes produced in the brain, if the emotions are of an exciting character; while if they are depressing, not only are changes of one kind, but of various kinds, checked or altogether prevented. It would also be inferred, that in different persons, and in the same person at different times, the emotions would differ very much in intensity. Especially when the brain is inflamed or the nervous system easily excited, it would be expected that the emotions would be easily excited and rendered intense; that in females the emotions would be more easily excited, more acute, and less enduring, than in man. Some would infer that the emotions are almost, if not entirely, physical —a weakness of the body that strength of mind is wanted to control; but it will be seen by the following paragraph, that the mind is the cause of emotions, and the brain merely the instrument.

649. The signs of the emotions can only be perfectly produced by exciting emotions in the mind. A person cannot cause the tears of pity to flow, without the feelings of pity are first produced; while if a person think of objects which will move his pity, the tears flow as a natural effect.

Persons who try to counterfeit the signs of pity do not succeed. Actors, instead of laboring to counterfeit the signs of the emotions, strive to counterfeit the emotions, or more properly speaking, cultivate the power of producing real emotions, whenever it is desirable, and the emotion once produced, the signs of it are exhibited as a matter of course, and without effort.

From this it is to be inferred that the mind is active in the production of emotions, and that the facility of producing emotions can be easily cultivated; also, that as certain emotions are healthful, they should be cultivated in the child by the parent, and in every one by himself; that the mode of cultivating the emotions is to present before the mind objects calculated to excite the desirable emotion; and that a speaker who wishes to be impressive, must not study so much how to make the gestures of emotion, as to feel the emotions he wishes to have act upon his hearers, when the gestures will be properly made as a necessary consequence; and the hypocrite may infer that, though he may "smile and smile," such language not being produced by real emotions, has a "*brogue*" which shows decidedly his true character.

650. Those parts of the brain employed by the mind in the production of emotions, cause in the mind four kinds of sensations.

a. A pleasurable sensation when the indulgence of the emotion is for the good of the individual and of society.

From this it is to be inferred, that the constitution of the brain is such that the changes taking place in it, under the action of the proper emotions, produce such a state as is agreeable to the mind. If, therefore, a similar state of the brain be produced by disease, or the action of medicine, the same feelings might be experienced. Hence we see that some diseases produce sensations as if emotions of the happiest character existed.

651. *b*. The exercise of the emotions to a certain degree produces feelings of exhaustion.

From this it would be inferred, that too long continued exercise of the emotions produces harmful changes of the brain, which time alone can re-perfect. When, therefore, wine or the like is used to produce such

a state of the brain that the exhaustion is no longer felt, and an excited state of the emotions may be continued, as when the same is done that a person may study after fatigue is produced, the most harmful consequences will result; sometimes such exhaustion of the mind and brain, that it can never be restored. It would also be inferred, that cool applications to the head and warm applications to the feet, rubbing the skin, and gentle muscular exercise, would be advisable under such circumstances, and especially before retiring for sleep, if the emotions have been active.

652. *c*. Certain degrees and certain kinds of emotions are disagreeable.

It is to be inferred that certain states of the brain, viz., such as exist in case of the emotions referred to, are intended to produce disagreeable sensations. If, therefore, the same state of the brain be produced by disease, the same sensation will be caused, and the sensations being similar, the cause will many times be thought to be the same. But melancholy feelings may be produced by disease of the stomach, or other parts of the body, and also by the sorrows of the mind. To remove these feelings, it is, therefore, sometimes necessary to remove physical disease, and sometimes to direct the attention of the mind from the cause of its affliction, by causing sensations which are of a different character to overpower those resulting from its sorrowful state. Hence why, for desponding states of the mind, the physician advises riding, journeying, new scenes, new faces, and whatever shall cause a variety of agreeable sensations, while in other cases a dose of medicine effects a cure. Hence is seen why changes in weather, by conducing to a certain state of the brain, will cause desponding feelings, from which a person only recovers with the return of fair weather.

653. *d*. When under proper circumstances the brain is not exercised by certain emotions, it causes sensations of uneasiness—a want that cannot be satisfied till the desirable exercise of the brain is allowed. Thus the mind must love at a certain period of life, and must have something to love. The most ardent attachment is sometimes seen for a dog, a horse, and those who are very dissimilar, to each other, as husband and wife, will love each other most devotedly. There is inexpressible delight in the exercise of this emotion,

and want of its exercise is insufferable by most of the human species.

From this it is to be inferred, that nature has constituted the brain in such a manner, that if the changes which take place in it when the emotions are active, are not produced, it will cause uneasy sensations, such as will at last compel a person to exercise those emotions, which are for his own good and that of his race.

654. We may now take notice of both the emotions and the thoughts.

a. It will be observed, that deep thought and intense emotion cannot take place together.

b. It will also be noticed that excitement of the emotions, from time to time, relieves from the fatigue of profound thought.

From these things it would be inferred, that the same parts of the brain are not engaged in the production of thoughts and emotions.

655. If an idea which may either awaken thought or emotion, be presented before a multitude even of educated persons—emotions rather than thoughts will be exerted in a large majority. Emotion is also exhibited earlier than deep thought; and by the most uneducated, in an intense degree.

It is to be inferred from this, that the parts of the brain employed in the exercise of the emotions, are more easily brought into action than the parts employed in thinking. That the emotions are the nearest avenues to the human mind, and the means by which many times thoughts can be awakened; for, if by exciting the emotions, an active flow of blood through the brain be produced, an increased flow must be received by the organs of thought, and, as we have seen, the circulation of blood through them prompts to thought. Hence, when a speaker's emotions are warm, they assist his thoughts.

656. We may now refer to the fact, that the attention of the mind may be given either to the sensations produced by thinking, by exercising the emotions, or by the action of the physical senses; and it will be found, that as the pleasure resulting from these last is the lowest, so it is the

most universal. It will also be found, that as the attention of the mind of the majority will be arrested sooner by a cause which excites emotion, than by one which excites thought; so it will be arrested more quickly by any thing acting upon the physical senses, than by any cause exciting the emotions. This indeed is the order in which attention should be arrested. Our physical senses warn us of *immediate* danger to ourselves. Our emotions excite us to protect society; while thought must take place without haste, and with time for deliberation.

657. The attention of the young child is chiefly to be occupied with physical sensations, as those are very early produced, and may be indulged without danger of overworking the brain; and it should be kept in mind, that while the mind is occupied with one sensation it cannot be with another. If, therefore, the mind be occupied with sensations produced by causes of a harmless character, the child will not cry for articles to eat, &c. As the child grows older, its emotions may be cultivated and the mind satisfied therewith; and as time advances, it may be gently led to think and to increase its desire for obtaining knowledge, and applying it for its own and others' good.

658. As in case of the muscles by exercise, gently and gradually increased in early years, the muscular man is produced, who not only uses his muscles with efficiency but delights in their exercise: so should the brain be fitted in early years, by gentle and gradually increased exercise in the fulfilment of all its duties of thinking, feeling emotions, and giving attention to physical sensations, to enjoy as it increases in years, all the pleasure which the world and its own powers are capable of producing. For though we know not on what peculiar property of the nervous substance its powers of acting depend, or what particular requirements are necessary in the fulfilment of its duties; though it is

generally denied to increase in size by exercise—and it would seem correctly—yet it would also seem, and I believe it will be universally allowed, to be improved in its powers, by exercise; and by gentle exercise in youth while it is growing, it is natural to suppose that its powers would receive a favorable direction, and be developed in a higher degree, than if its cultivation be neglected till advanced years.

659. In the fulfilment of all the duties of the mind, the blood being required by the brain in large quantity and of a pure quality; not only must attention be given to develop the mind by its own exercise, but to develop the powers of its organ, the brain, by muscular action, healthy, pure air—and in large quantities—taking wholesome food with a healthfully produced appetite, by the use of nature's beverage as a drink, great attention to cleanliness and activity of the skin, and an undeviating observance of the best habits in every respect.

Section 2.—*The Mind.*

660. The duty of the mind in the production of thoughts, emotions, and sensations, or the mode of fulfilling the duty, cannot be specified. Whether the nature of the mind is different in different individuals, or whether its apparent difference is owing *entirely* to the constitution and state of the brain, is disputed. That mental operations depend a great deal upon the state of the brain, is conclusive; but some suppose that certain duties of the mind are accomplished by the mind itself, without the employment of the brain.

661. Some think that the mind is a unit, others think that it may be considered as possessing faculties, one of which may be more efficient than the same faculty belonging to other minds. Some think also that exercise strengthens these faculties of the mind. Some think that the different faculties make use of different parts of the brain, and that of course there are as many divisions of the brain as there are faculties of

the mind. Some suppose that the faculties can be exercised separately, and thus are invigorated, while others may be enfeebled by want of exercise.

662. But in practical treatment of the body, all these persons very fortunately perfectly agree; and the rules laid down for the exercise of the mind, perfectly correspond with those by which exercise of the brain should be regulated. It is very happy for the physiologist, therefore, that it is not his duty to discuss the subjects of mental or moral philosophy, but that it is his privilege to leave those profound departments of knowledge in the hands of those learned men who have shown their ability to handle them with the most flattering success.*

* There is one thing, however, in respect to which the physiologist and physician must be humored. They must be allowed to maintain that insanity is the result of disease, that though it may be caused by the mind, *yet it never exists till disease has been produced;* and the individual exhibiting insanity should be considered as afflicted with disease, and looked upon with pity, not frowned upon by friends and neighbors as if he were laboring under some curse, nor should any unwillingness be felt by friends, or a person himself, to allow that insanity exists, if it really do—not more, that is to say, than in allowing the existence of any disease. Those noble institutions erected by many of our States, usually afford the best aid in the restoration of the sick who exhibit insanity; and it is well to take advantage of them before the disease has been long fixed, as the cure is at first easily effected in many cases, which, neglected in the outset from the wrong views of insanity that many entertain in not considering it a disease, never recover.

BOOK II.

SECOND CLASS OF ORGANS.

GENERAL OBSERVATIONS.

1. The organs described in the first book, require that four duties should be performed in respect to them.

2. 1st. They must be preserved of a proper temperature.

For when the skin becomes cold, the sensations are evidently blunted, a person rendered irritable, &c. If the head be hot it aches, and thought is confused.

3. 2d. The various parts of the body, as they become unfit for use, must be cast out of the system. This process is called excretion.

For it has been shown that action of the brain, the muscles, and it is supposed of any part, is attended with a wearing out, so to speak, of portions of the part used.

4. 3d. The parts which have become unfit for use and are removed, must be replaced by new material fit for use. Doing this is called the process of *nutrition*. The substance with which it is done is called nutritive substance, nutriment, &c.

5. 4th. During the early periods of life the various parts of the body must increase in size; accomplishing this, is also called the process of nutrition, and the substance with which it is done is called nutriment.

6. How the temperature of the body is preserved, will be understood by observing the habits of man and animals in different parts of the world. The first thing that strikes a person is, that nature has given man reason and ingenuity, by exercise of which he clothes himself, and protects himself and his domestic animals from the weather.

7. In respect to animals, it is observed that nature has given them instincts to seek refuge from the weather in burrows, in hollow trees, in nests or tenements which they build, or in the natural caves.

8. She has also given them a clothing, to some, of feathers; to some of wool; to some of hair; to some of fur; and her operations are so wonderful, that these coverings become thicker in the fall and remain so during the winter, but in the spring, the summer coat is regained and remains till fall.

9. To the swine, however, she has only given a thin coat of bristles, as an *external* coat. But directly within the skin is found a layer of fat, which is readily formed, and becomes very thick in the fall of the year. This, then, must be the protective coat of the swine. There are, therefore, two kinds of protection furnished to animals, viz., an internal coat, and an external coat.

10. To most animals she has furnished both, in a greater or less degree; to some but one. The hog can hardly be said to have any external coat. Man, frequently compared to the swine, is similar in this respect, nature furnishing him with the internal coat only, which in case of infants is usually very abundant, and if not too abundant, is exceedingly favorable to their welfare, by preserving in their little bodies, with comparatively large surfaces, the small amount of heat produced therein. Here it may also be observed, that nature has given the young of animals, which are lean, an instinct to come to the body of the parent for heat; see the chicken "brooding" under the wings of the hen.

11. The whale has also a thick internal covering. The water in which the animal lives renders it impossible for him to be supplied with an external coat. Some other kinds of fishes have no such internal coat. Some have it. The reason for the difference will be found in this. It is necessary for the whale to be kept warmer than the fishes without the internal coat. They are warm enough if they are a little warmer than the water in which they live. Some are not any warmer than the surrounding water, and if the water be warmed, they will remain cooler than the water. It is frequently observed, that placing a fish globe too near the fire kills the fish; the reason being, that the water is kept too warm for their health. But the whale, and all fish

with the internal covering of fat, must be kept much warmer than the water in which they live.

12. It seems, therefore, that the covering of an animal is thick, corresponding with the importance that it should be kept warm. Therefore, animals clothed with feathers should be very warm. It will be found that the lark is the warmest blooded animal of any known. Its natural temperature is about 117 degrees. *Therefore, the thick deposit of fat, in case of the child, shows that it is very important it be kept warm, and comparatively with after years, the importance of taking care that it be kept warm, is very great. In the first place, the organs of the infant are so little developed, it is doubtful whether it can perfectly perceive sensations; and indeed, it is doubtful if sensations are very perfectly produced. In the next place, if it perceive unpleasant sensations of chilliness or heat, it has not the power of telling its wants; it can only cry, which too frequently is misunderstood to signify a want of food.*

13. Most animals have not only the external coat thickened in the fall; but it is a thing of common note, that all animals fatten easily in the fall of the year. Man notices this in respect to himself. It may also be observed, that animals, including man, "grow thin" in the spring of the year, and remain so during the summer; the reason of which is perfectly obvious; yet many would desire to preserve their "plump appearance" in summer as well as in winter, and think health must be failing, when they perceive their weight to lessen, and consider this one reason why they should have recourse to "spring medicines;" all which ideas are evidently wrong.

14. In cold regions we should expect to find the internal and external clothing of animals very thick and protective. The long shaggy fur, and thick coat of fat possessed by the polar bear, justifies our expectations.

15. In warm regions, on the other hand, we would expect to find animals lean, and without external clothing. At first, the long furry coat of the tiger might disappoint our expectations, but one other consideration would satisfy our minds that the rule is of universal application, viz., the colder the weather, other things being equal, the more protective will be the external or internal clothing of any animal naturally exposed.

16. The clothing of man and animals is usually called protective against cold; so, also, is the shelter provided for animals. In common conversation this is well enough; but such language is not strictly correct,

and it is injurious, as it draws off the mind from seeing one important practical idea, viz., clothing and shelter protect the body by preventing heat from going out of it. There is no danger of cold coming in. Cold merely means, absence of heat, so when heat goes out of the body, the body, for want of the heat, is called cold.

17. If a person, when cold, retire to sleep in a cold chamber, he will wake in the morning not only warm himself, but he will find the clothing warm. He must, therefore, have produced heat within himself, which the clothing, to a great degree, has prevented from passing off. If he load the bed with sufficient clothing, he will wake and find himself too warm for comfort; he may be perspiring freely. This shows that *heat is produced in his body, even after it is warm enough for comfort.* It will now be seen that the quantity of clothing upon the bed, and which man or animals should wear, will *not depend merely on the coldness of the weather, but also on the amount of heat produced.* For it is evident if a certain temperature is to be preserved, and there is only little heat produced in the body, that little must be husbanded very scrupulously. When, therefore, we see the thick coat of the tiger, an inhabitant of a warm climate, we can infer that in his body very little heat, indeed, is produced, which must be very carefully preserved.

18. When we next inquire, by what means the heat is produced in the body, the attention will be directed to the fact, that man and all animals eat more in the winter than in the summer; much more in cold climates than in warm. Every one has noticed that the appetite diminishes in the spring of the year; and though many may think this owing to ill health, there is evidently a good reason why it should be so. It will also be noticed that the appetite is not as good in the warm days of winter, as in the cold. It will be noticed that the colder the weather is, the more do animals eat. It will be noticed that the more exposed to the cold a person is, the more does he eat; and that if he take a ride of a cold winter's day, it gives a keen appetite. It is evident, therefore, that the food we eat is the means of warming us, or has something to do with it.

19. It is also evident, that the better animals are protected by nature or by art, either in respect to shelter or clothing, external or internal, the less food will they require. The better stabled, the less will it cost to keep animals: a blanket upon a cow, will be as profitable as upon a horse. A fat animal, will eat less food than a lean one. An animal with a thick coat of hair, wool, or fur, will "winter" at less expense

than otherwise. A swarm of bees will not eat so much of their honey if their hive be kept in a proper place, as they will if it be exposed.

20. But when we take another view of the tiger, it is found that though he eats plenty of food, his furry coat exhibits that only a little heat is produced in his system. It will then be inferred that the *kind* of food that an animal eats, has something to do with the warming of his body. If we notice, we shall see that the tiger lives upon lean meat; and if the experiment be tried of throwing a piece of lean and fat meat into the cage of a tiger, he will be seen to carefully gnaw off the lean, and leave the fat. The polar bear, on the other hand, lives upon fat with delight; for, though he be warmly clothed within and without, his native region is the birthplace of the iceberg, and he requires much food of a kind that will make him warm.

21. It will also be noticed, that man is inclined to live upon one kind of food in summer and another kind in winter. Buckwheat cakes, with an accompaniment of syrup and butter, are highly relished in winter, but set aside in warm weather. In cold climates man finds the animals which he uses for food, fat; while in warm climates, they are lean: there also, fruits are more abundant, while in cold climates almost his only food consists of meat. The Esquimaux drinks the oil of the whale by the gallon.*

22. The squirrels also are plump and fat in the fall of the year, when they enter their holes; so also are the bears, when they go into their winter dens—but in the spring they are lean. That the fat is used on account of the cold weather, is evident from this; that the colder the winter, the more lean are all such animals when spring comes. Indeed, if the winter be very cold and long, bears frequently come out from their dens in the mountains of Russia and Switzerland, and driven by necessity for food to keep themselves warm, they will attack even man whom they otherwise shun. Bees also keep themselves warm during winter, by the use of honey. Cows and other such animals when driven by hunger in cold weather, "browse"—as the expression is—that is, feed upon the tender buds of trees. These contain gum in abundance. We are told also, that travellers in Arabia supply their wants while passing from one village or city to another, by a small quantity of gum. Gum is

* This, when fresh, is much like lard. In the summers of the temperate zone, vegetables are abundant; if the weather be hot, they will also be more watery; while, if the weather be cold, vegetation is less luxuriant and more solid.

also frequently given to the sick, as a kind of food very easily digested and very wholesome.

23. The kind of food which many, indeed most animals are fattened upon, indicates that starch is well adapted as food to warm the system; for the chief ingredient which renders grains, potatoes, &c., good to fatten animals, is the starch they contain. An experiment of throwing starch, fat, gum, sugar (for sugar may be taken to represent that class of food to which honey belongs), into the fire, will convince any one, that under certain circumstances they can produce much heat.

24. But upon further inquiry it is ascertained, that though an animal be well-fed, he will not be kept warm if he be placed in a cold situation and compelled to breathe bad air; or if a band be tied about his chest, so that he does not receive a sufficient *supply* of air, even if it be good. This would signify that pure air, and a good supply of it, are essential to warmth of the body—and thorough examination proves this; for those who labor in close apartments, are very liable to complain of cold and be "pinched" with it, when they go out. In cold weather, also, fires will burn more briskly than in warm. The air is adapted, in cold weather, to the production of more heat than in summer.

25. It is also found, that there is great complaint of suffering among those who restrain the action of the chest by tight dresses, or whose lungs, on account of disease, cannot receive as much air as is necessary for warming the body. Those animals, also, which are most warm-blooded, receive the most air in proportion to their size. Birds receive a great deal of air; for it not only passes into their lungs, but into their bones, and into various apartments of their bodies. The cold-blooded fishes are satisfied with what little air they obtain from the water; but the warm-blooded whale is furnished with immense lungs, which he comes to the surface of the ocean to fill with the pure air.

26. The extremities of the body are of a lower natural temperature than the central parts; the temperature rising as we pass from the surface of the body towards the heart, where it is found that all the blood in the body is continually flowing out to the lungs, from which it quickly returns a little warmer than it was. Again, when a person begins to take exercise, he begins to grow warmer, and at the same time he notices that the blood moves and he breathes more rapidly; from which it follows that when he exercises, more air acts on the blood in a given length of time, than when he is quiet. When the air is blown against coals, or when a draught acts upon the fire, it burns more rapidly

and causes more heat. It might be inferred that the greater the quantity of air acting on the blood in the lungs, the warmer would a person be.

27. Thus it may be considered as certain, that the heat of the body is produced by the food on the one hand, and by the air on the other. But in the next place, how shall it be distributed through the body? This could easily be accomplished by having a fluid continually moving through every part of the body, for if any part were warm the fluid would become warm, and if any part were cold the fluid would warm it.

28. But it is evident, that if the heat of the body should be continually produced, the body would grow too warm, and much harm would follow, as in case of fever. In this case it might be observed that the skin was dry, harsh, and hot, the brain delirious, &c. But as soon as a gentle perspiration breaks out, the skin becomes cool and flexible, the delirium subsides, and the doctor expresses hopes of his patient. In warm weather a person perspires freely, while in cold weather, perspiration ceases. An animal that sweats freely suffers but little from heat. The horse, intended by nature for active exercise and to produce much heat, sweats, and bears hard driving in summer weather while he sweats, but if the skin become dry, he will be injured except cooled by artificial means.*

The ox is easily killed, "melted" as it is termed, by over-exercise on a hot day. That animal does not sweat except by its tongue, which is kept moist and thrust from the mouth, as it will be by the horse if the case be extreme.

29. The dog is easily killed by over-exercise in hot weather, especially if fed upon food that tends to produce heat and fat, while if he be fed upon the tiger's food and kept lean, there is no danger. The dog is remarkable for "lolling," as the term is, and also for panting, which is merely a fanning operation. The air which he draws into his mouth, does not pass deeply into his lungs so as to produce much heat, but is merely drawn in and thrown out, to assist in cooling him by carrying away the moisture more rapidly from the tongue.

30. The effect of the perspiration in cooling the body is evidently the same as the effect of the water thrown upon the floor in summer: the

* If a horse driven upon the road on a hot day, be observed to become dry, which intense heat will frequently cause (it seeming to produce such a feverish state of the skin that it cannot sweat), it will greatly relieve the animal to dip some twigs with leaves upon them in water, and sprinkle the animal pretty effectually. It cools him.

water and the perspiration evaporate and produce coolness. In the Indies, before the introduction of ice, the people were in the habit of wrapping wet cloths around jugs filled with drink, and putting them in the sun, that the water might evaporate easily from the cloths and produce coolness of the drink. It is evident, then, that the perspiration is for the purpose of keeping the body properly cool.

31. But how shall the perspiration continue to ooze out of the body without drink be taken to supply it? It will also be observed, that a person drinks more in warm weather than in cold; those who work in warm exposures, for instance glass-blowers, perspire very much, and drink very freely. One office, therefore, of the drink, must be to cool the body, not merely by the coolness when swallowed, but by passing through the skin in the form of perspiration and evaporating from the body.

32. It might be asked, how shall the water drank through the mouth reach the skin? But by passing into a set of vessels or tubes, which lead into every part of the body, it could be distributed to the skin and thrown out, as the system might require.

33. To preserve the temperature of the body, these several things then will be required: 1st. Food of a proper quality and in proper quantity. 2d. An apparatus to prepare the food to fulfil its purpose in respect to producing heat. 3d. Air of proper quality and in proper quantity. 4th. An apparatus in which it may be received and caused to fulfil its duties. 5th. Drink and an apparatus for its reception. 6th. An organ through which it may be perspired. 7th. A grand apparatus of circulation to serve the various purposes of carrying the food and air, if need be, to where they are needed to produce heat, to distribute the heat, and to distribute the drink to the perspiring apparatus.

The Nourishing of the Body.

34. This is necessary on account of the continual wear of the system, and in early life on account of the daily increase from infancy to manhood in the size of the organs. The amount of nourishing to be done will therefore depend on the exercise of the various organs of the body, (for on their exercise depend the amount of their wear and decomposition) and on the rapidity with which the body is growing.

35. It will be noticed, that the more a person exercises, the more will he eat. The laboring man has a heartier appetite than the professional

man.* The animal that works hard has a keener appetite than the idle animal. When a child is growing rapidly it requires much food and has a hearty appetite.

36. It is therefore evident that the food affords nourishment, and if we examine the tiger again, we shall see that he is very strong, carrying off an ox with ease, it is said. If lean meat be little adapted to keep him warm, it is adapted to make him strong. The farmer finds, also, that buttermilk is adapted to his use, in the midst of the summer heats.

37. If we examine how this is, we shall immediately conclude that the food which is to nourish the body must contain the ingredients of which the body is composed. That milk contains these ingredients is certain, for we see all parts of an animal to be formed of milk. A calf, for instance, eating nothing but milk, grows large and strong. The milk must contain all the substances necessary to form the bones, the nerves, the brain, and every part of the animal. So a chicken comes out of the shell, its bones, its flesh, and all its parts being formed from the contents of the shell. Whence eggs must be very nourishing.†

38. It may be proper in this place to mention, in further explanation of this matter, that the whole world is composed of some fifty-six different substances, some of which exist in very small quantities. Water is composed of two of these substances, called oxygen and hydrogen. One other substance called carbon, added to oxygen and hydrogen, forms *fat*. The proportions of the three substances being varied a little, sugar is formed; being varied again, starch or gum will be formed. Thus all the various things with which we are acquainted, are made up of some few things united in certain proportions. In the human body, thirteen different substances are *always* found. *So many are necessary.* Some of them

* This tends to show that fatigue after the use of the muscles is owing to the state of the muscles, and not merely to the state of the nervous system. For without doubt the professional man uses the nervous system more in thinking, than the laboring man in the same length of time; but the laboring man requires more food to replace the large amount of his muscles which has become unfit for use during his labors.

† It seems a fortunate thing that eggs are plenty in the commencement of summer, that very time when food is required which shall be nourishing and not warming; and that the egg does not contain much substance adapted to the latter purpose is evident, from its being necessary for the hen to keep the eggs warm with the heat of her own body. The chick in the egg is not able to keep itself warm, and after it is hatched, it is necessary for some time that it obtain a great part of its heat from an external source.

are in very small quantities, but they are always present, and the body cannot exist without every one of the thirteen, composing it. There are usually nineteen different substances, but of the last six sometimes one and sometimes another is wanting. If, therefore, a person growing should receive but twelve out of the thirteen necessary substances, he could not live long. Hence nourishment must contain the necessary constituents of the body—not that every portion of nourishment must contain each of the thirteen, for as only a small quantity of some of the thirteen is required, if they are used occasionally it is sufficient. More upon this point hereafter.

39. The food for nourishing the body appears so unlike, in many instances, the various parts it is to nourish, it is evident it must undergo some process of preparation. But in the next place it is evident it must be carried to every part of the body where it will be required. To accomplish this, nothing seems more desirable than to have it become part of the fluid which is moving through every portion of the body. Nothing therefore is required for distributing it, in addition to the apparatus necessary for preserving the temperature of the body.

The Process of Excretion.

40. This is rendered necessary by the constant action which is taking place in the various organs, on account of which parts of them become unfit for use, or are decomposed, as the expression is. It is easy to see that three things may be true of the substance decomposed in the organs: 1st. The whole or part of it may be of use in nourishing, that is, supplying the wants of some other part of the body. 2d. It may be of use in the production of heat; and the increased heat attendant upon taking exercise of any part, points very strongly that way. 3d. A part or all of it must be cast out of the body as unfit to fulfil any duty therein, having performed the office for which it was designed. And sooner or later this is what must take place, in order that we may account for the large amount of food which persons every day use.

41. The first thing necessary, however, in regard to this substance thus become unfit for use, is, that it be removed from the organs in which it is unfitted any longer to serve a useful purpose; for if it remain, it will only clog their action and produce unpleasant sensations. This can be accomplished in the easiest manner, by having the substance pass into the vessels before shown to be required, and become a part of the fluid that they contain.

42. The second thing necessary is, to have this substance subjected to such an action, that if it contain any substance profitable in any part of the body, or adapted to produce heat, it may be retained, and the remainder cast out of the system.

43. In the duty of excretion, therefore, one or more organs will be required, through which the fluid containing the decomposed substance may pass, and be acted upon as the case may require.

The Nervous System of Organic Life.

44. But when there is much exercise, much substance will be decomposed; there will then be required increased action of the excreting apparatus, the nourishing process must take place more rapidly, a greater appetite will be necessary, and the circulation of the fluid containing the decomposed substance and the nutriment must be hurried. So also if a person be exposed to great heat or cold, the action of the respective organs having duties to perform in reference thereto, must be increased or diminished.

45. To accomplish what will be necessary in these respects, a nervous system will be required, which shall bind, so to speak, all parts into one. This nervous system must consist of one or more centres, upon which the states of any and all the organs of the body shall act, and from which effects shall be produced on any or all parts of the body, as the necessity of the case shall require.

46. From these various organs of the second class there must also be communication with the mind, upon which at times they can produce effects, that its assistance may be given in the fulfilment of duties which could not otherwise be accomplished. But that every act of these organs should be brought before the mind would not be at all proper, for as the processes referred to in the previous paragraphs of this book are constantly taking place, the attention of the mind would be so occupied that it could not attend to its legitimate business. It is like the arrangements in a grand manufacturing establishment; the mind has a general oversight, and constantly exerts an unseen influence, but is only called on to give particular attention here or there on especial occasions; but is left to do the "out-door business of the concern"—the thinking, the "buying and selling," &c.

The divisions which will be made in the second book are now evident.

CHAPTER I.

THE DIGESTIVE ORGANS.

47. These receive the food and drink, and through these the drink without preparation, and the food after being subjected to certain processes, pass into the bloodvessels. The action of the digestive organs upon the drink is, therefore, very simple; but the food is submitted to three different operations before passing into the bloodvessels. The first takes place in the mouth, the second in the stomach, the third in the second stomach.

SECTION 1.—*The Mouth.*

48. This may be divided into the front mouth and the back mouth or upper part of the throat, the part commencing at the back part of the tongue and leading above into the nose, and below into the gullet, meat-pipe, swallow or œsophagus, and into the windpipe; it is technically called the pharynx.

49. The front mouth every person understands, it being so readily presented to view. In this the food is subjected merely to a mechanical process. It is ground, masticated or chewed, and mixed with the saliva or spittle. The same process might be accomplished in a mortar if a proper portion of food and saliva were ground therein.

It is a very important process; for it is found that if the food be swallowed in haste, being but half masticated, dyspepsia soon follows; it is also found very difficult to fatten animals which have lost their teeth, without very soft food be given to them. That it is important

saliva should be mixed with food, is evident from the provisions of nature. The young of all animals which yield milk, obtain their food by drawing or sucking it into their mouth, by which means a large quantity of saliva is mingled with the food. Chewing the food has been so arranged by nature as to cause saliva to flow into the mouth in large quantities. It has also been found in certain diseases, where the saliva has not been formed, or if formed, lost by flowing through an opening in the cheek, that digestion of the food in the stomach did not take place well. Dr. Beaumont found also, that if food, unmixed with saliva, were placed in the stomach, it did not digest well. Persons who *drink* milk, often notice that it does not "set well upon the stomach." All nations, so far as I can learn, with milk eat bread or some like substance, which, by requiring to be chewed, may supply the proper quantity of saliva; they having learned by experience that this is better. *It is therefore to be inferred, and held as a golden rule, that a child should never be fed with a spoon, but caused to draw the food into its mouth by sucking, according to the intentions of nature.*

50. The mouth may, therefore, be considered under four divisions: the teeth, the skin lining the mouth, the salivary apparatus, the muscles which move the jaws and bring the food under the teeth, and which, after the food is prepared, pass it into the back mouth.

A. *The Teeth.*

51. These are firmly placed in the jaw by the parts called the roots or fangs. Another portion of the tooth is covered by the fleshy gum, the remaining portion projecting into the mouth, is called the crown of the tooth.

52. The outside of the crown is a hard, thin shell, called the enamel, covering the part within, as the thimble covers the end of the finger. The inner part of the tooth and the fangs, except a central canal, (Fig. 86), is composed, in fact, of two kinds of substance, one called the cortical and the other the ivory of the tooth; but usually the distinction is not noticed, and the whole is called the ivory. It is not as hard as the enamel.

Fig. 86.

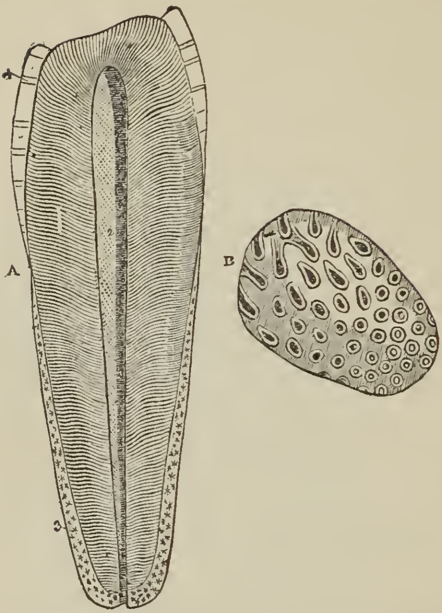


Fig. 86.—A, Perpendicular section of a molar, magnified four diameters. 1, Ivory with wavy tubes, the openings of which are seen at 2, the canal for pulp, central nerve, &c. 3, Is called the cortical portion, and forms the outside of the fang. 4, Enamel worn away at the summit of the tooth. B, A greatly magnified view of a section across the tubes.

53. The enamel is destitute of nerves, and of course never causes any sensations. In the ivory of the tooth, there must be a great multitude of nerves; it is so very sensitive at times.

Whether these are branches of the nerves found in the central canal of the tooth, and called by way of distinction, the nerve of the tooth, or are branches of nerves entering the tooth from the outside, is uncertain.

54. There is a delicate skin covering the fang and neck

of the tooth. This, when diseased, causes very acute pain if touched ever so gently.

55. The use of the enamel is to preserve the internal part of the tooth from exposure, for as soon as the air, the fluids of the mouth, or the food or drink, act on the inner portion of the tooth, they cause it to decay. The enamel has, therefore, been made hard that it may not be easily worn away, but on this account it is easily cracked by hot or cold articles of food or drink; for as a cold tumbler will crack if put in hot water, because the heat swells the outside of the tumbler before it has time to act on the inside, and as a warm tumbler cracks when put in cold water, so will high and low temperatures act on the outside of the tooth before they do on the inside. If the teeth be examined, in many persons the enamel will be found full of cracks, looking like a "glaze-cracked plate," or other articles.

56. Through these cracks substances find their way to the part within, and before a person is aware that decay is begun, the tooth is a "mere shell," viz, nothing but the enamel is left. Very hot or cold drinks, iced waters, especially when preceded by a cup of hot tea or coffee, iced food, iced creams, iced desserts, are not only unnatural, but must be very injurious to the teeth. Eating snow, sucking icicles, &c., should be avoided.

57. The hardness of the enamel is not only observed to differ in different persons, but in the different teeth of the same person. The color of the enamel is different; it crumbles very easily in case of some of the teeth, slivers off in case of others, while in other teeth of the same person, the enamel is solid, good colored, and enduring.

It will also be noticed, that teeth grow in pairs, and that the appearance of the teeth in the same pairs is similar. If one tooth of the pair decay, the other will soon follow, showing that the same causes which operate on one injuriously, act in the same manner upon the other; that, therefore, as the teeth were made at the same time, so they were made alike.

58. There are evidently two things which would affect injuriously the formation of teeth; disease of the apparatus forming the teeth, and a want of proper material from which to form them.

Disease of the apparatus forming the tooth is found to exhibit itself most usually in the form of the tooth, which will have a "ridgy" or "wavy" that is, an uneven surface, while a want of proper material would be naturally exhibited in the too great softness of the tooth, or its tendency to crumble, &c. That such a state would frequently be produced is only what would be expected by the educated person, who sees the mother setting aside the perfect milk, containing all the ingredients to form the teeth and every other part in a proper manner, and feeding her child upon "pap" and like substance, in the composition of which, some of the most important ingredients of the teeth are entirely wanting.

59. But though the enamel was intended by nature to be hard, it yet was intended in man to be used on food much softer than itself, for it is to last an entire life-time.

The teeth of the squirrel are continually growing at the roots, he may therefore gnaw the hard shell of the nut without danger. But the boy should be warned against cracking nuts between his teeth, or biting pins, or breaking hard substances with the teeth, or prying upon the teeth with any thing hard, like a knife. The girl and lady who care either for the beauty or health, arising from preserved teeth, should be careful not to bite hooks or eyes, or bite off threads with the teeth, as there is danger, especially if a tooth happen to be of a crumbly character, as is frequently the case with the teeth of ladies.

60. As the enamel of the teeth is so liable to become cracked, it is exceedingly important that the teeth be kept clean: for bits of food, &c., being allowed to remain about the tooth and decay, will produce acids, which "soaking," through the cracks of the enamel, will exert an injurious influence upon the ivory of the teeth. Many recommend to wash the teeth after each repast, but they should be thoroughly cleansed twice per day, on rising in the morning and retiring at night, the mouth being not only rinsed out, but the teeth brushed above and below as well within as without, and the brush should be carried up and down as well as across the teeth.

61. If the teeth are not frequently brushed, not only do substances from the food remain about the teeth, but a substance from the fluids of the mouth is apt to deposit and harden on the teeth. It is called tartar, and seems almost as hard as bone in some cases. It is of a brown or black color, and besides giving a very bad appearance to the teeth, tends to work down beneath the gum and loosen the teeth in their sockets,

producing also a very undesirable red, swollen and spongy appearance of the gums.

62. If the tartar have formed unawares to a person, he should have it immediately removed. If it have caused the gums to be diseased, they should be freely washed with cold water and gently brushed with a soft brush.* If a tooth have begun to decay, it should be attended to at once. The decayed portion must be entirely removed and the place filled with gold, if possible ; but if the tooth be "too far gone," the author can testify from ten years' experience with one tooth, to the wisdom of having the cavity filled with a composition made by the dentists. If the tooth can neither be filled nor pulled, a little pulverized charcoal held in the mouth several times per day, will somewhat correct the bad breath arising from decayed teeth.

63. If the gums remain spongy for several weeks after all the tartar has been removed from them, and they have been repeatedly washed with water, the attention of the physician had better be invited, as disease of the stomach and its connections is very frequently indicated by the appearance of the gums.

64. Tobacco is sometimes said to prevent the teeth from aching and decaying. It cannot do the last, but on the other hand, dentists testify that men using tobacco are more troubled with decayed teeth than those who do not use it. It can do the first, by producing such a state of the nerves that they have not the power to produce sensations, but the tooth continues to decay if the nerve do not give warning of it. Therefore the tobacco is doubly injurious, it increases the decay of the teeth, while at the same time it does not allow its ravages to be made known to the mind.

65. The teeth are thirty-two in the adult ; in front, four above and four below are called incisors, or cutting teeth. Back of these, one above and below on each side are called cuspid, (spear or one-pointed,) canine or dog teeth. Back of these upon either side, two above and below, are called bicuspid, from having two points. Three on each side, above and below, are called the grinders, from their use ; and one of these

* Indeed a softish rather than a hard brush is preferable for any gums.

upon each side above and below, farthest back, from not appearing till between the years of 15 and 25, is called the wisdom tooth (Fig. 87).

Fig. 87.

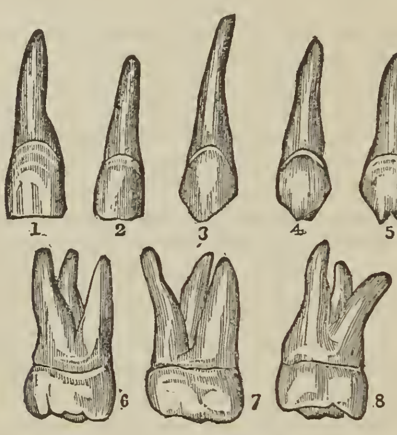


Fig. 87.—1, 2, Incisors.—3, Cuspid.—4, 5, Bicuspid.—6, 7, Molars.—8, Wisdom.

66. These take the place of the first set, though larger and more numerous, the jaw having "grown." The first set usually disappears before the *appearance* of the second. But sometimes a tooth of the first set is allowed to retain its place, and the tooth of the second set is obliged to appear on one side or the other of its true place, disfiguring a person or injuring his speech. A first tooth should always be "pulled" in season. The position which the first teeth occupy is not of consequence, nor is the position of the second teeth, provided they be upon the ground which they ought to occupy. That is, if they be turned to one side or the other, it is not of much moment, for very frequently the jaw has not enlarged sufficiently to allow all the second teeth to make their appearance in due season and in an even manner; but as the jaw enlarges, they will become even and properly adjusted, or if they do not, and there be room for the adjustment, the dentist can easily by springs, &c., move the teeth till they are right. If the jaw do not become large enough for the teeth, one tooth can be drawn, and this will give room for the rest.

It is now seen why the wisdom teeth appear so late; there is not room for them in the mouth till maturer years.

67. The second set of teeth begins to form a long time before the first ones "become loose;" in the earliest infancy their formation is progressing.

Hence the material for the second set of teeth must be furnished to the babe even, that their foundation may be good

B. *The Lining of the Mouth.*

68. This is very much like the external covering of the body, and by some is considered a continuation of it. It is composed of two layers; the external is called epithelium, and corresponds to the external layer of the skin (the cuticle), but is much thinner and more delicate. In the lining of the mouth there is no coloring matter.

Hence the blood of the skin gives it a red appearance, and the brightness or paleness of the red, indicates the health of the system in many cases, particularly the health of the lining of the stomach and bowels, as the same lining of the mouth continues on through the throat, to line the stomach, second stomach, &c.

69. The second layer of the lining of the mouth is called the chorion. It is the essential part, the external layer being merely a protection. In the second layer the bloodvessels and nerves are found. Near to its surface the bloodvessels form a network of superlative delicacy and beauty. Some parts of its surface are formed, as may be seen on the tongue, into prominences called papillæ. In these some, perhaps all, the nerves of the lining commence.

These nerves must be threefold, as heretofore seen; by one kind a person tastes; by another he feels: and there must be another kind to connect this part with the nervous system spoken of in the general observations, and called the organic system, its nerves being called organic nerves.

70. In this lining there is found a multitude of little

pouches or sacs, called cryptæ. They are like those of the external skin in their appearance, but in them is formed a kind of glutinous substance called mucus ; it can be seen by scraping the tongue with a spoon or knife. It is formed from the blood.

Its character of course will depend upon the quality and quantity of the blood and the character of the apparatus forming it, which is itself dependent also upon the quality and quantity of the blood, and the organic nervous system before mentioned. This system, as heretofore proved, influences the circulation of the blood through each and all parts.

Thus, looking in the mouth to learn the state of other parts of the body, is not useless ; for the color of the mouth will indicate the activity of the circulation of the blood, especially in the lining of the stomach, &c., and the vigor of the nervous system, at least in respect to these parts. The character of the mucus will be another indication of the character of the blood and the nervous system, especially as it respects the stomach, second stomach, &c. And it has been found by various means, that when the lining of the mouth is "sloughed," the stomach is in a similar condition ; when the throat has a certain red appearance, the second stomach is in a similar state, &c.

71. The use of this mucus seems to be to preserve the lining of the mouth in a good condition, and perhaps it is of use by being mingled with the food ; remaining in the mouth, however, during the night, it frequently produces a "bad taste." To remove it by rinsing the mouth with cold water upon first rising, is a good habit. This habit also tends to prevent the deposit of tartar upon the teeth, and awaken an active circulation of the blood in the lining of the mouth, thus giving a good color to the gums. If at the same time the throat be well gargled, it will tend to prevent swellings of the throat and soreness of the back mouth and throat, and the "hanging down" of the palate so frequently complained of.

C. *Salivary Apparatus.*

72. This consists of six glands, three upon either side of the mouth, and tubes leading from the mouth to them.

But firstly, it will be best to describe the general principle upon which all glands are formed, since though the various glands of the body differ in particular arrangement, the same general plan is observed in all.

73. *Glands* are for the purpose of presenting a great extent of surface in a small space. The simplest form of a gland is that of a crypta, seen in Fig. 76. A more compound, but yet very simple gland, is seen in Fig. 88; while a compound gland with all its essentials is presented in Fig. 89. By this it is seen, that a gland is nothing more than a tube with a great many branches, about which there is an infinite number of cryptæ, and thus an immense extent of surface obtained. Sometimes the tubes have no cryptæ, but are very long and coiled around so as to be packed in small compass; sometimes other ways of gaining the same end are used.

Fig. 88.

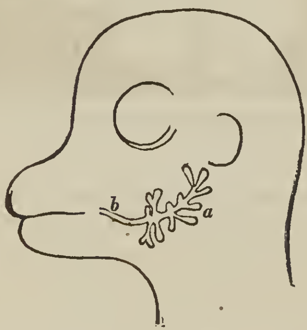


Fig. 88.—*a*, One of the simplest glands of an animal. *b*, Tube opening into the mouth.

74. The next essential thing is a great multitude of blood-vessels about the sides of these tubes in the glands, and a circulation of a great quantity of blood from which the fluid of the gland may be formed. In the next place, there must be nerves connecting between the gland and the mind, for when the salivary glands are affected with the mumps, they ache, and also when the mind thinks of any delicious food, the saliva is rapidly formed. There must also be a connec-

Fig. 89.

Fig. 89.—Part of a compound gland, with tubes and cryptæ laid open. The black lines represent the larger bloodvessels of the part. The causes and appearance of the lobules are also seen

tion between the glands and the organic nervous system, because the saliva being formed from blood and formed very freely, when we are eating, and at other times, in accordance with the wants of the body, there must be some cause for the increased circulation of blood required under such circumstances.

75. The tube and cryptæ of a gland, whatever form they may have, are in fact nothing more than the lining or skin of the part into which the tube opens, slightly and but slightly changed in its texture, and existing in that form for the purpose of presenting much surface in a small space ; for instance, the skin lining the mouth is formed into a tube commencing at the centre of the cheek, at a slightly roughish place easily felt with the tongue. It leads to the back part of the jaw, being readily felt like a cord beneath the skin upon the outside of the cheek. At the back and side of the jaw, just before the ear, it forms branches. These subdivide, and about the twigs, cryptæ are formed. Between these is

found a kind of soft cellular flesh, called the parenchymatous substance of the gland. Enclosing the whole a delicate skin grows, and the apparatus is formed, and upon receiving the blood and nervous influence begins to act.

76. Why, when the glands are so similar in their structure, the different kinds form such dissimilar fluids, is at present inexplicable. It may be owing to some difference which has not been perceived in their structure; it may be owing to the differences excited by the nervous system upon the different glands, or both causes may combine to produce the effects seen. It would seem to depend much upon the nervous system, since when disease prevents one part from fulfilling its duty, it will sometimes in a measurably good degree, be performed by one which in health performs an office somewhat similar, perhaps, but yet different.

77. The small tubes and cryptæ belonging to any one branch of the grand tube form what is called a lobe, and smaller branches of the larger form lobules, &c.

The uneven appearance of the surface of many glands, is owing to the lobules, as in case of the salivary glands.

78. The salivary gland just described, and its fellow upon the other side, are called the parotid glands. They are about the size of a dove's egg, or a little larger. Underneath the under-jaw, about two-thirds of the way from the centre of the chin to the lower back corner or angle of the jaw, and, as it were, between the jaw and tongue, a gland about the size of a robin's egg is found; it is called the submaxillary (under-jaw) gland. Tubes from these open in the sides of the bottom of the front part of the mouth, near by the "string" which ties down the tongue.

79. A short distance in front of these, and rather more under the tongue, is found a gland, not as large as a sparrow's egg, with several short tubes opening directly above and in front of the gland. This, with its fellow, is called a sublingual (under-tongue) gland.

.80 These different glands seem to differ somewhat in their structure and in the influences acting on them. The under-tongue gland is seldom diseased, or its disease attracts little attention. The under-jaw gland is

liable to several diseases; to the "mumps," more frequently than the sublingual, but less frequently than the parotid, and to enlargement and hardening very frequently. This seems to be, sometimes at least, the consequence of using hard water, or is aggravated thereby. The progress of disease is usually so slow, that attention is not called to the importance of the complaint, till it is too late for the surgeon to give advice with the best effect. When this gland begins to enlarge, it may be safely judged that something serious is affecting the system and that very judicious advice should be taken and followed for a long while. The most common disease of the parotid is the "mumps," a disease sometimes affecting one parotid, sometimes the other, sometimess both; sometimes one parotid and one submaxillary on the same side, or on the other, or all the glands at once, or several, or all of them in succcession. Sometimes one at one time, and another at another. But seldom if ever does the disease exist twice in the same gland. This is a matter of great surprise, for the structure, duty and mode of accomplishing it, are the same to all appearance, before as after the disease. and yet the gland is so altered in regard to its structure or the nervous influences it receives, that it cannot be affected by the same causes that produced the "mumps." The same is true of other diseases, viz. whooping cough, small-pox, measles, &c.; though sometimes the system is not so changed by these diseases that it cannot be affected to a degree, a second, or even a third time, though always lightly. An important question in regard to these diseases and the changes they produce is, are they natural, and do the changes they produce in the system fit it to contend with other causes of disease to better advantage? It would seem from what evidence can be gained, that those who have all those diseases, as they are called, that affect the system but once, in their childhood, and are well taken care of, so that they entirely recover, are longer lived and hardier than others. All such diseases seem to be more fatal when taken in advanced life. The mortality formerly attendant upon small-pox, can well be accounted for by the treatment pursued, as at the present day few if any die. In olden times a great-grandfather of the writer being taken with the small-pox in the course of his practice, according to the approved method of that day, without a reason to sustain it, immediately shut himself in a close room, kindled a fire to keep the apartment very warm, and of course in a few days died. People now ventilate their rooms very perfectly, eat but little food, keep the bowels gently open, remain quiet, and if confined to bed, change and air the clothing and bed itself very frequently; keep themselves cool and calm as possible, avoid all causes

of chills, such as draughts of air, &c.; drink no stimulants, but as much cool (not ice) water as the thirst craves; gargling the throat with the same frequently if desirable. This course, with slight variation, and the administration of some medicines as the physician may think a peculiar case requires being carefully followed, a person recovers in a short time, not of small-pox merely, but of scarlet fever,* measles, mumps, &c. To return to these last, many, indeed most persons when affected by the mumps, immediately cover the face with a handkerchief, &c., and confine themselves to the room or house. But the opposite course is advisable, to which the writer can testify from recent experience. Nothing should be used to cover the face, but the face over the region of the disease should be sponged with cold water; avoid taking cold, eat lightly, keep the bowels open, breathe pure air, and take light exercise.

D. *The Muscles of the Mouth.*

81. These may be considered as forming three classes. 1st. Those which raise and depress the jaw, and move it from side to side. Those which raise the jaw are four in number upon each side. The temporal muscle will be felt by placing the finger upon the temple while chewing, and if the thumb be placed upon the jaw below, the masseter muscle will be felt (Lith. Pl. 1, Fig. 1). Within the jaw, and passing from it to certain projections or processes at the bottom of the skull, two other muscles, called the internal and external pterygoid, are found (Fig. 90). They assist in raising the jaw, and when those upon either side act, they move the jaw inward upon that side; then the opposite muscles contracting will produce a grinding motion of the jaws. They can also shoot the jaw forward.

The muscles that draw the jaw down are numerous, and are not worthy of mention, except the digastric, described in a previous paragraph.

82. 2d. The muscles of the tongue. Some of them

* Some do not think this contagious, or at all belonging to the catalogue of small-pox, measles, &c. In some respects it does, in others not.

Fig. 90.

Fig. 90.—The two pterygoid muscles. The zygomatic arch and the greater part of the ramus of the lower jaw have been removed in order to bring these muscles into view. 1, The sphenoid origin of the external pterygoid muscle. 2, Its pterygoid origin. 3, The internal pterygoid muscle.

reach from the centre of the chin directly back into the body of the tongue, others turn upward to the tip, as seen in Fig. 91. Some reach forward from the bone at the base of the tongue to the tip, the tongue being composed almost entirely of muscular fibres; by the contraction of some or many of which, the varied movements of the tongue are produced. The use of these movements in eating, is to roll the food under the teeth; to gather it into a ball when it is to be swallowed, and pass it back to the throat.

83. 3d. The muscles of the cheeks (Lith. Pl. 1, Fig. 1). They are of use in bringing the food under the teeth, and also assist in taking the food and drink into the mouth, especially when taken by sucking; they also close the mouth. They are also muscles of expression, as it is termed, and are so numerous that it is easily seen how, by a slight peculiarity of the different muscles, different expressions will be given to the features.

84. All the muscles of these classes depend upon the blood for their vigor, and as the circulation of it is under the control of the nervous system of organic life, the muscles must be connected with it; as they must also be, that the changes taking place in them may go on regu-

Fig. 91.

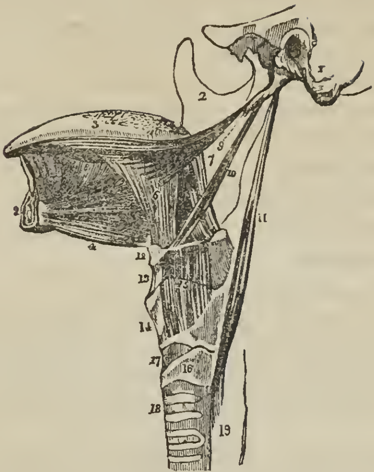


Fig. 91.—The styloid muscles and the muscles of the tongue. 1. A portion of the temporal bone of the left side of the skull, including the styloid and mastoid processes, and the meatus auditorius externus. 2, 2, The right side of the lower jaw, divided at its symphysis; the left side having been removed. 3, The tongue. 4, The genio-hyoideus muscle. 5, The genio-hyo-glossus. 6, The hyo-glossus muscle; its basio-glossus portion. 7, Its cerato-glossus portion. 8, The anterior fibres of the lingualis issuing from between the hyo-glossus and genio-hyo-glossus. 9, The stylo-glossus muscle, with a small portion of the stylo-maxillary ligament. 10, The stylo-hyoid. 11, The stylo-pharyngus muscle. 12, The os-hyoides. 13, The thyro-hyoidean membrane. 14, The thyroid cartilage. 15, The thyro-hyoideus muscle arising from the oblique line on the thyroid cartilage. 16, The cricoid cartilage. 17, The crico-thyroidean membrane, through which the operation of laryngotomy is performed. 18, The trachea. 19, The commencement of the œsophagus.

larly. All these must also be connected with the mind, as they obey the mandates of the mind when it desires them to contract, and their states sometimes produce pain. The muscles of the face seem to be peculiarly connected with that part of the brain or nervous system acted upon by the emotions: for all the passions and emotions of the mind are usually expressed with more accuracy by them than they could be by any language. The permanent feelings of the mind always stamp themselves upon these causes of the features. Knowing this, a person should beware of trusting to his power of putting on a Sunday face; his muscles of expression will betray him. These muscles, from disease of the nervous system, are sometimes paralyzed, or one class, or part of a class only, or by a different disease of some part of the nervous system,

they are thrown into action, which the mind neither produces nor controls. The tongue will be thrown out, and frightfully bitten by the muscles suddenly closing the jaws; at the same time, the muscles of the face producing hideous contortions of the features. Sometimes the nervous influence, instead of acting at intervals, is by disease caused to act continuously, closing the jaws firmly and producing lock-jaw, or perhaps acts on all the classes of muscles with similar effects.

85. The muscles of the face, of the tongue, and of the jaw, are also divided into those of the right and those of the left side, which receive their nerves from the two sides of the nervous system.

Thus the muscles of one side may be paralyzed, and those of the other side sound, drawing the face or the tongue to that side, the jaw upon the diseased side dropping down. Other diseases of the nervous system may exhibit themselves, of course, in a similar manncr in the muscles of either side, according as the nervous system of either side is affected.

86. *Back mouth.* At the sides of the commencement of this, are found what are called the amygdaloid (almond-shaped) glands. Their particular use is not known.

They are frequently swollen as one of the effects of colds, and frequently become enlarged, producing a difficulty in breathing, swallowing, and speaking, which is often overcome by gargling the throat with cold water.

87. Above the base of the tongue, the soft palate is found hanging in the back part of the mouth, arched upon either side of a central point, commonly called the palate, but properly the uvula. The soft palate is formed mostly of muscles, covered by the lining of the mouth, which passes round the edge of the palate and covers the other side of it, which becomes the floor of the nose.

88. The central point of the palate, the uvula, often becomes too long, and hanging down, it produces almost constant tickling and inclination to cough. The application of gargles of cold water, or more astringent substances, usually are sufficient for this evil; if not, a portion of the part must be clipped off.

89. The action of some of the muscles of the palate can raise it to a horizontal position, when it will reach to the back part of the throat, and cut off all communication with the nose. The action of the other muscles will draw the soft palate close upon the tongue, and close the passage from the throat to the front mouth.

90. Below, the throat or back mouth terminates in the œsophagus and the windpipe, which is placed beneath the back of the tongue. The opening into it is at its upper and back part. Over this opening a thin piece of flexible cartilage is placed, attached to the under part of the tongue and upper front edge of the windpipe. This valve, as it is sometimes called, can be easily felt by the finger passed along over the back surface of the tongue. Against this the windpipe is raised up when food is swallowed into the throat, sliding over the opening, into the meat-pipe, gullet, swallow or œsophagus.

91. This is a tube represented by Fig. 25, from nine to eighteen inches in length, composed of muscular fibres, lined with a continuation of the lining of the mouth. Food which is swallowed into this tube, tunnel-shaped above, is immediately pressed upon by the upper muscles of the upper part of the œsophagus, and thus forced down a little, when another portion of the muscular fibres contracting, it is forced down still further, till by the successive contraction of the different parts of the swallow, the food is deposited in the stomach.

92. When the tube is empty, the sides are in contact with each other; it can be distended from half an inch to two inches in different persons. When substance is thrown up from the stomach, a contracting action of the œsophagus takes place from below upwards.

Sometimes as the food is swallowed, the fibres above the food contract, while those below either convulsively contract, or refuse to relax or

open. This produces acute distress, but usually only for a moment. Similar pain is felt sometimes from swallowing a larger mouthful of food than a person ought. Other causes sometimes detain the food in the throat. If the substance be of a harmless character, it may be forced down into the stomach by a smooth piece of ratan, whalebone, or pliable "sprout" of a tree. Whatever is used should be quite flexible, yet pretty strong, and about as large as a pencil-case—a little larger or smaller, as is convenient. One end should be covered with a piece of fine sponge strongly tied on with thread, or a bit of cloth will be better than nothing; if nothing else be at hand, a green shoot of a tree can be bruised with a stone so as to be somewhat soft, or it can be made very smooth and thus used. The gullet is directly in front of the back-bone, so that if the head be put back as far as possible, the opening of the mouth is nearly in a line with the meat-pipe, and any thing can easily be passed, even by a child, through the mouth and throat into the stomach, and by a stick or the like, food could be forced on. If any thing like a fish-hook, pins, needles, &c., be lodged in the meat-pipe, a large piece of sponge tied around the end of a stick can sometimes be forced down the gullet, carrying with it the harmful object, which will not prove as obnoxious in the stomach; or if the sponge can be crowded past the object, in being raised it may remove the object also. The surgeon should be called in such a case as soon as possible, as his ingenuity and experience may expedite matters more skilfully than others. Sometimes the physician will think it advisable to give an emetic by injecting it into the veins, when it will soon cause the stomach to throw off its contents, which may bring up with them the cause of trouble.

93. There is one thing in respect to the muscles of the œsophagus worthy of notice. They are not under the control of the mind. A person can swallow any thing into the throat, but once there, he has no further control; neither can he produce the movements of swallowing, except by passing something into the throat. The muscles of the meat-pipe must of course receive nervous influence from some source. It is not the action of the food when touching the muscles which causes them to contract, for it is those just above the food, which by contracting, press the food along; therefore it must be, that when the food touches one portion of the meat-pipe, an effect is produced upon the nervous system of organic life, and then an influence is exerted upon the muscular fibres just above where the food touches the œsophagus. Here is seen another duty of the organic nervous system, viz., to cause certain muscles to contract; and likewise another illustration of the fact, that the mind is re-

lieved of all duties that can be well performed without its supervision. There is, however, a connection between the mind and these muscles, as is evident from the pain they produce.

94. Toward the lower extremity, the œsophagus comes forward, and a little to the left of the back-bone, terminating in the stomach nearly on a level with the lower point of the breast-bone, and a little to the left of the centre of the body.

Section 2.—*The Stomach.*

95. The food, when swallowed from the mouth, is not different from what it was when received into the mouth, except that it is, or should be, ground finely and mingled with saliva. It is in the same condition when it reaches the stomach as when it leaves the mouth. In the stomach it is to undergo what may properly be called a change—a change which requires considerable time—and also that the food be mingled with certain fluids formed in the stomach for their peculiar purposes. The stomach must therefore be a pouch of considerable size—the size varying as the case may require, for sometimes much food and sometimes but little is required. The stomach must be so constructed that it can mingle its juices with the food, and must receive a large supply of blood, from which its juices are formed, and the supply of blood must vary as the system requires the preparation of much or little food. Nervous influence must also be exerted upon the stomach, that the fulfilment of all its duties may be regulated. The stomach must also be connected with the mind. All these things are found to exist as it would be supposed they should.

96. As the stomach is hidden from our view under ordinary circumstances, it might be thought by some, that statements in respect to the operations of this organ must be entirely conjectural; and so they were till within a few years. In the year 1822, however, a young man, Alexis St. Martin by name, a Canadian by birth, but at the time in Michigan in the United States service, was accidentally wounded by the discharge of a gun; the muzzle of which was about a yard behind and a little to the left of him, and pointed across his side, which was torn open by the buckshot and somewhat burnt by the powder with which the gun was

loaded. Dr. Beaumont, U. S. surgeon, was immediately called. He found, as he says, a portion as large as a turkey's egg, of the left lung, pushed out through the opening made; and noticed, also, that the food eaten for breakfast by St. Martin about an hour before, was passing out in a half-digested state. Of course, the stomach was injured. Strange to say, in about ten months after this St. Martin was well, to the great credit of Dr. B. Still more strange, and fortunate for the world and apparently without injury to St. Martin, though the opening in the side closed up so as to cover in the lung, the edges of the wound in the stomach refused to "grow together," but grew to the edges of the external wound in the side—thus leaving an opening, about two and a half inches in circumference, through the side into the stomach. Through this opening any thing could be passed into, or taken from the stomach; or the stomach could be examined under any different circumstances. In about ten months from the recovery of St. Martin, a kind of valve or apron began to grow down from the upper edge of the opening of the stomach. It hung, so to speak, within the opening like a curtain, retaining the food; but it could be pressed in, and the stomach examined as before. Dr. B. hastened to improve the opportunity; and with much apparent accuracy and particularity, made notes of his observations and experiments. With *his* notes in hand, and the results of so many experiments as have been tried on man and animals, we may advance to the subjects under consideration with considerable assurance of being compensated with positive knowledge.

97. The stomach is situated in that part of the trunk, called the abdomen—the large cavity found below the diaphragm (Lith. Pl. 3, Fig. 1). The diaphragm is a muscular and tendinous partition, arching upward very much. It is connected by its outer edge to the ribs and cartilages at the bottom of the chest, to the lower part of the breast-bone and to the back-bone. It forms the roof of the abdomen, which from the arched form of the diaphragm, reaches up under the ribs more or less according to the arch of the diaphragm; and that varies very much on two accounts, as in Figs. 92 and 93. For as the ribs are raised up when the breath is drawn in, as every one can perceive is the case by placing the hands upon the sides and inhaling a full breath, the arch of

the diaphragm will be less unless it passes up at the same time, instead of which it is brought down by the contraction of the muscular part of the diaphragm.

Fig. 92.

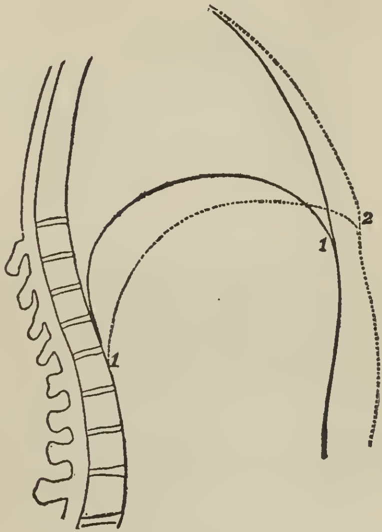


Fig. 92.—The back-bone is easily recognized. The pillars of the diaphragm are connected with it at 1, which is not a movable point, as is 1 at the opposite and front side of the chest, which, when it is raised up, carries the point 1, outward and upward to 2. The continuous line 1, 1, is the diaphragm when the breath is thrown out; and close underneath it, the liver and stomach are situated, as in Fig. 96. The dotted line 1, 2 is the position of the diaphragm when contracted at the same time the chest is raised, and of course the organs of the abdomen are pressed down and outward by all the space between the line 1, 1, and the dotted line 1, 2. The dotted line beneath 2 is the wall of the abdomen, when the diaphragm is contracted. The line beneath 1 is the wall of the abdomen, when contracted.

98. The sides of the abdomen are essentially composed of several layers of muscles, (Lith. Pl. 1, Fig. 1,) covered by the skin without and lined by a skin or membrane, called the peritoneal coat. When the stomach, second stomach, and other organs of the abdomen are full, the muscles are dis-

Fig. 93.

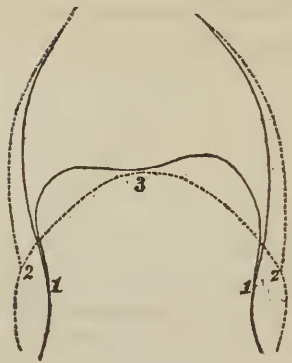


Fig. 93.—Back view of a perpendicular section of the lower part of the chest and upper part of the abdomen, through the centre of the body. The continuous lines show the outline of the body and diaphragm when the sides of the abdomen are contracted, and the diaphragm and the levator muscles of the chest relaxed. The stomach, liver, &c., are closely drawn up underneath the diaphragm, as in Fig. 97. The dotted lines exhibit the outline of the body and diaphragm when the chest is raised up, and of course the points 1, 1, carried outward to 2, 2, and the organs of the abdomen are pressed downward and outward, distending the sides of the abdomen, as seen below 2, 2, or felt by the hands placed on the sides of the abdomen when the breath is drawn in. At 3, it is observed that the dotted lines are but a little below the position of the continuous lines. That point of the diaphragm is nearly stationary, above it the heart is found; and the partitions upon either side of the heart, dividing the chest into three apartments, are attached to the diaphragm, and with other causes prevent extensive movement of that point, which is not only unnecessary but would be injurious. Upon either side of 3, the arches of the diaphragm are seen; upon the right, the arch is naturally the greater, owing to the position of the liver beneath it; which causes also the arch 3, 2, to be more distinct than represented by the dotted lines.

tended; when these organs are empty the muscles contract so as to produce a constant, greater or less, pressure on the organs within the abdomen. The abdomen is always full: therefore, if there be but little in it, the abdomen is small in external circumference; if the abdomen contain much, the external circumference is correspondingly large.

99. When, therefore, the arch of the diaphragm is drawn down in breathing, the organs of the abdomen must be pressed down, and also compressed if the muscles of the side of the abdomen do not yield or relax; and by placing the hand upon the abdomen when the breath is drawn in, it will be perceived to distend, thus giving room for the organs

pressed down by the diaphragm. Again, it will be seen by Lith. Pl. 1, Fig. 1, that some of the muscles of the front part of the abdomen stretch from the ribs to the front part of the pelvis. Except, therefore, these muscles relax, the ribs cannot be raised up as they are when the breath is drawn in.

100. The muscles forming the walls of the abdomen relax, therefore, to allow the diaphragm to press the organs of the abdomen down, and to allow the ribs to be raised.

101. The contraction of the muscles of the sides of the abdomen will have just the contrary effect, viz., it will draw down the ribs and press upon the organs within the abdomen, and cause them to press upon the diaphragm, and press it up if it be relaxed; if it be contracted, the organs of the abdomen will be pressed upon, and if with sufficient force their contents will be discharged—as when in vomiting, the stomach is so forcibly pressed as to overcome the lower rings of the œsophagus, which by contracting, retain its contents.

102. The force with which the muscles of the abdomen will press upon its organs, will depend in the first place, upon the contents of the organs.

If the organs be full, as is noticed after a hearty dinner, the pressure will be considerable; and breathing is performed with difficulty, because the diaphragm finds a difficulty in pressing down the organs of the abdomen, when, by their fulness, they have already distended the sides of the abdomen almost to their limit. While, if little has been eaten, the movements of the diaphragm may be extensive and performed with ease; hence why a person speaks or sings with ease, "on an empty stomach."

103. The pressure upon the abdominal organs depends, in the second place, upon the position in which a person stands, or sits.

If the body be erect, the muscles of the sides of the abdomen are made tense, or the opposite of relaxed, and the sides of the abdomen cannot of course be easily distended; more force is exerted upon the abdominal organs, and the diaphragm is drawn down with greater difficulty, and the ribs also raised with greater difficulty; that is, the breath is drawn in with greater difficulty. If the body be somewhat bent, how-

ever, the muscles are correspondingly relaxed and the breath drawn in with ease—as the organs of the abdomen are compressed but little. Hence when a person has eaten a hearty dinner, he sits in a curved posture, and when the stomach, bowels, or other organs of the abdomen are sore upon pressure, he places a pillow under his shoulders and draws up the knees—as then the muscles are relaxed; and when he wishes to draw in a full breath, he also curves his body forward a little.

If on the other hand, the body be very much curved, the muscles of the sides of the abdomen must contract very much before they will begin to press upon the contents of the abdomen, and thus cause the breath to be thrown out, while if the body be erect, a very slight contraction of the muscles will exert great force. Hence the position which is best for drawing in the breath is not the best for throwing the breath out. Thus powerful singers will be observed to take advantage of each position of the body, curving forward a little when the breath is drawn in and straightening themselves up, and indeed curving slightly backward sometimes, to give the muscles great power in throwing out the voice. It would seem therefore, that no one position is always right, but that any position is sometimes right. An intermediate posture between very straight and curved, being the general direction best to follow, especially during sleep; but a frequent change of posture is evidently the intention of nature, and all supports and articles of dress which prevent the rising of the ribs or distention of the muscles of the abdomen, are evidently injurious.

104. The pressure exerted upon the organs of the abdomen will depend, in the third place, upon the health of the muscles.

This varies much in different persons, and can be improved by a judicious course of training. This is accomplished by a course of reading, singing, speaking, blowing upon wind instruments, or any exercise calling into action the breathing muscles, gentle at first, but made more severe as they gain strength.

105. The pressure of the muscles upon the organs of the abdomen depends, in the fourth place, upon the exercise of the system.

Almost any exercise increases the action of the breathing muscles, and some kinds, such as lifting, &c., produce immense pressure upon the contents of the abdomen.

106. On every account it will be found that the stomach has a most favorable location. In the upper part of the body a framework was necessary to support the arms, and within this the lungs and heart might be most advantageously placed, while the stomach required a position where it could increase or diminish in size, as the necessity of the case required, viz., as the system should require much or little food. Gentle pressure while the stomach is digesting food is also highly advantageous to its action. The abdomen is therefore precisely adapted to the wants of the stomach, while every action of it is equally advantageous to the heart and lungs, as hereafter shown.

107. The stomach is a muscular pouch or bag, covered with a membrane called the peritoneal coat, and lined with what has the several names of mucous coat, villous coat, lining membrane, &c.

108. The muscular coat is itself composed of several different layers, the fibres in one layer passing around the stomach, as in Fig. 26; the fibres in another layer passing from one extremity towards the other. In another layer the fibres pass across the fibres of the other two. In the human stomach the layers are not very readily separated, for the fibres of the layers are interwoven with each other very intimately, and the whole thickness of the stomach is not very great, and the muscles of it are, therefore, correspondingly delicate. In a piece of tripe, (the stomach of a beef,) which is thick, the layers are very readily seen. By the contraction of the circular fibres of the large extremity, the food will be passed into the small extremity, the fibres of which must relax, and vice versa, the contraction of the circular fibres of the small extremity of the stomach will press the food back again. The contraction of the longitudinal fibres of the stomach will draw the extremities of the stomach towards each other, while the contraction of all the muscles of the stomach will lessen its size in every direction. The covering of the stomach will be spoken of hereafter.

109. The lining of the stomach is a continuation of the

lining of the mouth and œsophagus. It is, however, somewhat altered in appearance, and has some new duties to perform. Like the lining of the mouth and throat, it contains many cryptæ, from the mouths of which, a slimy substance, like that of the mouth, flows out upon the lining of the stomach.

Whether in a healthy state of the stomach the quality of this substance varies at different times, that is, whether more is formed when food is taken than when the stomach is empty, is not known. It is formed from the blood, and of coürse its quality and quantity will depend upon the quality and quantity of blood from which it is formed, the healthy state of the apparatus in which it is formed, and the state or power of the nervous system which causes it to be formed.

110. The whole inner surface of the stomach is formed into innumerable points, like the "nap" of very delicate velvet. They are called villi, and give the stomach a kind of fleecy, velvety, cloudy, and very delicate appearance (Fig. 94). Their specific use is not known.

Fig. 94.

Fig. 93.—Portion of the lining of the stomach.

111. The chief office of the lining of the stomach, is to form, from the blood, a fluid called the gastric (stomach) juice. Its appearance to the eye is that of spring water. It has no very peculiar smell or taste, varying in these respects in different cases. But it has a very powerful and peculiar effect upon food submitted to its action. In a short

time the food will undergo a change, very apparent to the eye, smell, or taste.

In what, however, its properties consist, or how it produces its effects, or what precise changes take place in the food by its action, has never yet with certainty been learned. It is curious, for instance, that the slightest difference, either in smell, taste, or looks, cannot be detected between the gastric juice of a dog and that of a sheep; and yet grass will remain unaffected in the gastric juice of the dog, and meat, in like manner, will not be acted on in the gastric juice of a sheep.

112. In what particular part of the lining of the stomach the gastric juice is formed, is not determined. It appears in the stomach very much as perspiration appears on the side of the forehead, viz., it is seen starting out over the inner surface of the stomach, in very minute drops, which are sometimes poured out so freely that they gather into larger drops, or even trickle down the sides of the stomach as the perspiration sometimes streams down the face.

113. The quantity and quality of the gastric juice will depend upon the quantity and quality of blood from which it is formed; the condition of the apparatus in which it is formed, and the health of the nervous system, by the influence of which it is formed.

114. When the system was healthy, gastric juice was found by Dr. B. not to be continually formed, as the saliva is, but only when food was required and swallowed. If food were taken when it was not needed by the system, the gastric juice would not appear, and of course the food could not be acted upon. But it would act on the stomach very injuriously, producing inflammation. *To eat food when it is not needed, is therefore exceedingly injurious.*

115. If the system needed food, and unwholesome substances were swallowed, the gastric juice would only make its appearance for a few moments. The unwholesome and indigestible substance would remain in the stomach for a time, tending to cause disease.

116. If the system needed food, and wholesome food were taken, the gastric juice would continue to come into the stomach for from 5 to 30 minutes, and more or less freely, according to the requirement of the system for food, and not according to the amount of food taken.

117. A given quantity of gastric juice could only digest a given quantity of food.

If therefore more food were taken than the system required, the gastric juice which would be formed, would not be sufficient to digest all the food taken; and not only would some of the food remain for a time undigested, but all of it would be a longer time in digesting, than a proper amount would have been, and the stomach soon become deranged by such a course. A person should, therefore, eat *only as much as the system requires.*

118. When the system was diseased, the gastric juice would either not be formed at all, or in very small quantities, and of a bad quality; and food taken then, though the system appeared to require it, would be imperfectly digested, and even that would require a long time. When, therefore, *a person is unwell, it will be useless to take much food,* to say the least, as it cannot be digested.

119. Many causes increased and diminished the flow of the gastric juice. The smell of food, and still more the taste of relished food, would prepare the way for a free flow of the gastric juice. Lively feelings and a cheerful disposition were very favorable to the formation of a large quantity of gastric juice. Spices and stimulating food or drinks, for a few times increased the quantity, but after a little time diminished as much as they had increased it. Angry feelings, a melancholy thought, or the mind engrossed with business, would prevent the formation of gastric juice, though food were taken, and in fact required by the body.

This shows that the mind has a powerful influence over the digestive process, is intimately connected with the stomach, and that a person who would live long, should learn to love wholesome food, eat it

with a relish, preserve an agreeable disposition, and devote time from his business to eating, and avoid brandies, spices, &c., which for the time quicken an appetite only to *permanently derange the stomach.*

120. As the gastric juice is formed from the blood, it would be expected that the flow of blood would be increased and diminished at such times as the gastric juice was formed in large or small quantities, and this Dr. B. found to be the case, viz., the same causes which would cause a free flow of gastric juice into the stomach, would cause a free flow of blood through the stomach, as would be shown by the color of the stomach, which when it was healthy and empty, was a yellowish ash with a slight pink shade, ripening when required food was taken, to a deep red blush, which continued while the gastric juice was forming; but when that was produced in sufficient quantity, the lively color of the stomach subsided.

Feelings of anger would cause the stomach to become pale and comparatively bloodless.

121. As such an active circulation of the blood is required about the stomach that the needed supply of gastric juice may be formed, it will not be proper to produce an active circulation in the brain by intense study or application to business, or an active circulation in any other part by energetic exercise of it, during the first part of the digestive process. And as a little time is required to turn the circulation from one organ which has been very active, to another which has not been in action for some hours, a short period of rest should be taken before a repast.*

122. If it be necessary to eat immediately after severe labor or mental exercise, or if it will be necessary to labor or exercise immediately after eating, it is evident that only a small repast should be taken, for only a small amount of blood can be allowed to the stomach, only a small amount of gastrice juice can be formed, and only a small quantity of food can be digested.

Many people, when journeying by public conveyance, feeling a hearty

* No man would think of feeding his horse as soon as he stops, when on a journey. Why not treat himself as reasonably?

appetite, eat much food, swallow it hastily, and finish their tour with fatigue, headache, &c. Lighter repasts will enable a person to endure more, and at the end of the journey, after a few hours' rest, the appetite may be indulged with profit.

123. For the same reasons, very much food should in no ordinary cases be taken before retiring to sleep. If no food have been taken in a long while previous, and the system seems to feel the need of some, it may be used, but very sparingly, because the circulation of the blood is not active in any part of the body during healthy sleep.

124. The circulation of the blood may, however, become too active, as in case of inflammation, when the gastric juice will be no longer produced. The blood may all become stagnant in the bloodvessels, which contain perhaps a large quantity of blood, but it is not of a proper quality; such a state is called congestion.

125. Owing to disease or some other cause, the gastric juice may be formed in some parts of the lining of the stomach, but not in others. Extensive disease affects some parts of the stomach, while other parts perform their duty quite well. Canker may affect certain parts of the mouth without disturbing the rest, so it may the stomach.

126. Besides the three coats already mentioned, some count a thin layer of cellular substance, between the middle and outer coats, as a fourth and a similar layer between the middle and inner coat as the fifth coat of the stomach.

127. The stomach has two openings. One through which the food passes into the stomach, is called the œsophagial, cardiac (heart, from being near the heart), and the first opening. It is situated a little to the left of the centre of the body, and about one third the distance from the large, towards the small extremity of the stomach. It is closed by the contraction of the lower rings of the œsophagus.

128. The other opening is several inches to the right of the centre of the body, and nearly on a level with the first opening, and at the small extremity of the stomach. It is lled the pylorus (porter), because it opens and closes to allow

food to pass from the stomach or retain it there. It is closed by a strong band of muscular fibres, which in man appear very much like the other rings composing in part the second stomach, only they are more distinct, and in some animals, for instance the turtle, a fold as it is called, a kind of "tuck," (a lady gave me the expression,) is made by the lining of the stomach at the pylorus. In this fold a ring of muscular fibres is found. An approach towards this is sometimes found at the pylorus of the human stomach.

129. The form and size of the stomach differs in different persons, and in the same person at different times. The muscles and other coats of the stomach distend as the food is received at any time, while by overfeeding, the utmost ordinary capacity of the stomach can be very much increased. The general form of the stomach when moderately distended, is exhibited by the various figures of the stomach; but when empty it becomes small, both on account of the contraction of its muscles, and because the pressure of the other organs, and the muscles of the abdomen will crowd it into a small space, as a glove might be, when the hand is withdrawn.

130. The position of the stomach is seen in Lith. Pl. 3, Fig. 1. It is supported there by ligaments, sometimes called roots, which extend from the upper part of the stomach, that is, the part between the openings of the stomach, to the backbone, these confine the upper portion and the openings of the stomach very nearly to one position; but some motion is allowed to them, while the other portions of the stomach are allowed to hang downward, project forward, or be pushed upward, according to the fulness of the stomach, and the pressure of the parts surrounding it and in a measure supporting it. The position of the stomach very much depends, therefore, on whether it be full or not; if it be full, it occupies much space, if it be empty, but little. The large ex-

tremity, in particular, occupies much space when it is full. The position of the stomach, full or empty, changes as the breath is drawn in and thrown out; the degree of change depending on the fulness of the breath.

131. We may now give attention to the operations taking place in the stomach when wholesome and required food is taken. 1st. The stomach distends to receive it. 2d. The redness of the stomach increases, owing to the increased circulation of blood in the stomach. 3d. The gastric juice makes its appearance. 4th. The muscles of the large extremities begin to contract, and force the food towards the small part of the stomach, mixing it together, and also with the gastric juice. 5th. The temperature of the stomach rises, owing to the increased circulation of blood. 6th. The food thus churned, so to speak, by the action of the muscles of the stomach, begins to be acted upon by the gastric juice, and undergoes that change commonly called digestion.

132. The action of the muscles of the stomach is at first slight, but in a short time increases, and continues till the food passes from the stomach, though it grows feeble toward the last. Violent exercise of any other part of the body, and depressing states of the mind, check it, while rest and reasonable vivacity increase it.

133. The gastric juice continues to appear in the stomach till there is sufficient to digest the food, if too much be not taken. The lively red appearance of the stomach continues during the same time. The same causes as check or increase the action of the muscles, act favorably or unfavorably on the formation of the gastric juice.

134. The change is gradually perfected in a portion of the food first; that part leaves the stomach through the pylorus, while the rest remains to pass through the necessary change, when, little by little, it all follows the same way; toward the last it passes out much more rapidly than at first.

135. There is something singular in the action of the pylorus in this matter. If the smallest portion of well-digested food touches the inner or stomach surface of the pylorus, it relaxes and allows it to pass, but as instantly contracts when any undigested portion touches its inner surface. If also any unwholesome food have been taken, it will closely contract and retain it in the stomach, till after a time it may be thrown off by vomiting, if that be best; if not, it will relax and allow the indigestible food to pass. If the portion of indigestible food be small, such as seeds, &c., it will allow it to pass rather than compel the stomach to cast off a large amount of wholesome food. In early life, when it might be expected that inexperienced childhood would eat too much, and also unwholesome food, the pylorus is very apt to refuse undigested food to pass its portals.

136. It cannot be that this action of the pylorus is controlled by the mind; but it must be dependent upon the influence of the nervous system of organic life. Its regularity must therefore depend upon the general health of the body, and it must become irregular when the health is deranged.

We may now give our attention to the food, the changes it undergoes in the stomach, and what facilitates these changes.

1st. *The Chemical Nature of the Food.*

137. The food must be in part composed of those substances, elements, or compounds, which are found in the body.

The bones, for instance, are composed of lime, and they cannot be kept in good condition without lime be eaten in certain proportions. But the lime which is eaten for the good of the bones, must be combined with certain other things before it is taken into the mouth. For if lime should be put in water and drank, or in any way swallowed into the stomach, the bones would not be benefited. Oxygen and hydrogen united in certain proportions, form water; but if a person should force oxygen and hydrogen into the stomach, it could not form drink of them. A bit of fat is composed of oxygen, carbon, and hydrogen. If these substances, not combined, should be taken into the stomach, it could not form fat of them.

138. Food, therefore, must not only be in part composed of the same elements as the body, but these elements must be combined in a certain way.

To combine them in certain ways, plants are needed. In them, therefore, strictly speaking, the first process of digestion is performed. The sugar-cane has its roots in the ground, its stalk and leaves in the air, and both roots and leaves are refreshed with water. From the air, earth and water, it selects the ingredients of sugar, viz. carbon, oxygen, and hydrogen; and combining them in a proper manner, sugar is the result. The sugar taken into the mouth is crushed and mixed with saliva, then swallowed into the stomach, where it undergoes a change which is usually called the first process of digestion. It then passes on, and at last is separated into its original elements or an approach towards them; for instance, it may be into oxygen, and carbon, and hydrogen; or the oxygen and hydrogen may remain united, if in proper proportions, forming water, and the carbon may be left by itself, or the carbon and hydrogen may be left united, and the oxygen released. Our knowledge of the changes is not very definite; but when the substance serves its use, the combination of its elements is broken up, and they are ready to be cast out of the system, and be again combined with each other in plants, and again eaten.

139. Thus it is with all the articles used by the system. They are composed of the simple elements, as they are called, united together, and forming what are called the compound elements of food. The compound elements are formed in plants from the simple elements, called also ultimate elements. When a creature eats these plants, it eats the compound elements, called also proximate elements, and the compound elements become parts of its own body: if man or other animals eat the flesh of a creature, he or they eat the compound elements of which the creature's body was composed, and which were obtained by the creature from some plant. The compound elements may thus pass along, from the plant to an animal, and from animal to animal, till at last in the body of some one they are used, and become decomposed into their simple elements, when the office of the plant will be again required.

140. The compound elements are rarely found alone in the plant. When the sugar is pressed out of the cane, there is a great deal of husk left; when starch is taken from a potato, there is much substance left. Those animals therefore, which live upon plants, will require an apparatus to separate the compound elements in the plant from the other portions of the plant, which as food are of no use to the animal. For instance, an animal eating the sugar-cane must be supplied with an apparatus for extracting the sugar and any other substance that may be of use to the animal. Man grinds the cane in a mill, and by the exer-

cise of his ingenuity, contrives a press to extract the juice, but the ox must grind the cane in his mouth, and extract the sugar in his stomach.

141. Those animals, therefore, which live upon plants directly, will require a more extensive apparatus than those animals living upon the flesh of other animals. Those animals which live upon plants, or those parts of plants which contain comparatively a small quantity of the compound elements, would require a more extensive digesting apparatus than those animals intended by nature to live upon those plants, or parts of plants, containing a comparatively larger amount of the compound elements.

142. Thus it is found that the digestive organs of animals living upon plants, such as grass, grains, fruits, &c., have very extensive digestive organs. The cow and sheep have four stomachs, &c., while those animals like the tiger, &c., which live upon other animals, have very simple digestive organs; while those living upon the grains or seeds of plants, have a less extensive digestive apparatus than those living upon all parts of plants.

143. The next question is this: Does the system select from the food eaten, all the compound elements it contains, or only that portion of them the system at the time requires?

This is uncertain. The probability is, that sometimes it does, and sometimes it does not. The system seems to have a strong inclination to lay up a store of fat if proper food be eaten, especially in the fall of the year, and this not as a covering for the body merely, for it is stored away in the internal parts of the body as well as directly under the skin; but how much of the other compounds it will take from the food against the future wants of the system, is uncertain; doubtless some, but not much.

144. Food may then be divided into two kinds; one the useful part, composed of compound elements, the other, useless or waste, and consisting of those parts of the food not composed of compound elements, and such of the compound elements as are not wanted (if there be any such) by the system.

Whether man should partake of both kinds will be discussed when speaking of the second stomach, as both kinds require the same treatment till they arrive in the second stomach.

2d. *Preparation of Food for the Stomach.*

145. As these compound elements must be carried into every part of the body through vessels exceedingly small, it is necessary that they should be reduced to a very finely divided state, for which purpose the teeth have been provided in the first place. These, therefore, should be thoroughly used.

Dr. Beaumont testifies, that food was a long time in digesting in the stomach, except it were well chewed. Indeed, if the food were swallowed or put into the stomach in large pieces, it would remain there so long as to cause disease of the stomach. He frequently tried the experiment of hanging meat, &c., in the stomach of St. Martin, and always found that if such experiments were tried for several days in succession, inflammation of the stomach would appear. Persons should not, therefore, hurry the food into the stomach, but take time to enjoy it; and if there be but little time to eat, then eat but little, but do it well. Children should be taught not to swallow half-chewed food, both by example and precept.

146. If the food be thoroughly chewed, it will also be well mixed with saliva—an important thing, as by softening the food, if nothing more, it causes the juices of the stomach to act easily upon the food.

147. Food should also be such that it can be properly chewed and mingled with the saliva. Such things as are not acted upon at all by the teeth, should not be eaten; and much care must be taken in eating radishes, cucumbers, raw potatoes, &c., that they be thoroughly chewed, otherwise Dr. B. found they would not be readily digested. Food should also be cooked in such a manner, that it can easily be chewed, and will easily be saturated with saliva. Rare baked or boiled potatoes, for instance, are very unwholesome; solid bread, heavy pastry in which there is much fat especially, must be very unwholesome. Hard-boiled eggs are bad; indeed, the food should always be prepared so as

to be light, easily chewed, and easily saturated with the juices of the mouth and stomach.*

3d. *The Quantity of Food.*

148. This depends, in the first place, upon the health of the system.

As heretofore shown, there cannot be a healthy circulation of blood about the stomach, nor gastric juices properly formed, when the system is unhealthy. Under such circumstances it would be useless, therefore, to take food even if the system needed it. In such a case, the proper way is to treat the system in such a manner that it will not need much if any food, viz., it must not be vigorously exercised or much exposed to cold. If exercise be absolutely necessary, the system can certainly be protected by extra clothing, but extra food must not be used; for how can the system when unwell accomplish the double task of taking the exercise and digesting food? It is singular that a person does not always reflect, that if the system be feeble it cannot digest food; that when it exhausts him to "sit up" or move about, the powers of his body are certainly not sufficient to the task of preparing food for use. Let this be considered a rule of the highest importance—WHEN UNWELL, EAT BUT LITTLE; the less the better. Many a fit of sickness will thus be avoided.

149. In the second place, the quantity of food should depend, if the system be healthy, on the kind of food eaten.

If the food contain much waste substance, a greater quantity will be required to satisfy the wants of the system. If the system require food to warm it, while the kind of food eaten contains few of the compound elements adapted to that purpose, a large quantity of food is required. Thus by not eating the right kind of food a person may derange his system, as he compels it to digest a larger quantity of food than its powers can endure; as it is easily conceived that the food may be of such quality, that the powers of the system would be exhausted, before it could digest so large a quantity of food as would contain the ingredients required for its use.

150. In the third place, the quantity of food should de-

* Since the saliva is so important for the digestion of the food, those people must do themselves much harm, who by using tobacco, prevent the stomach from receiving its proper portion.

pend, if the system be in health and proper food eaten, upon the amount of exercise taken.

As exercise wears out the system, viz., causes the compound elements to be decomposed into simple elements, new material must be eaten in corresponding ratio.

151. In the fourth place, if proper food be taken in a healthy state of the system, its quantity should depend upon the growth of the person.

When the body is growing, it must receive in the form of food, the ingredients by which to increase its size. If these do not exist in the food, or if so much exercise be taken that all the usable ingredients of the food are required to supply the place of the worn-out substance of the body, the body cannot increase in size ; hence poor food and hard labor will check the growth of the young, especially as the body must use all the useful parts of the food in fitting the body to endure the labor that is inflicted upon it. Hence the curse of those manufacturing establishments in the old world, where *children* are necessarily employed and half-fed, to make the products of labor cheap.* If the system be using the ingredients of the food in increasing the size of the body, it would be natural to suppose the body would soon be weakened by active exercise, and its parts comparatively weak and imperfectly formed. Much rest is, therefore, needed at such times.

In this connection, an explanation may be given of the cause for fishes being supported in a common fish-globe, the water being changed once in a day or two. The fish has but little opportunity to exercise, and of course can require but little food to repair itself ; if plenty of food of a nourishing quality be given to it, the fish will grow most wonderfully.

152. In the fifth place, the quantity of food should depend, if the body be healthy and the food proper, upon

* It is to be hoped, as the laws have already done something to remedy in this country the growing evil, that ere long it will be seen that the good of community and the cause of humanity demand the curtailment of the tyrannical power exerted by some parents, who, to support themselves in the lowest kinds of dissipation and idleness, make slaves of their children—their own flesh and blood—and confine them to labor under the most unfeeling taskmasters, the whole weary day ; till the life, the ambition, the pride of youth become stupidity, submissiveness, and indifference.

whether it be desirable or not to increase the fat in the system.

It will be impossible to "fatten" man or animals, if there be not more food taken than is sufficient to supply the nourishment required by the daily exercise of the body, and to keep the body warm; nor can the fat of the body be formed, if the powers of the system be exhausted in their efforts to warm and repair the body; for those things must be done before fat will be deposited. It is therefore evident, that little exercise and want of exposure, and much food, will tend to increase the fat of an animal; while over-exercise or great exposure to cold, or want of food, will prevent the deposit of fat. A horse over-driven will not grow fat, nor will an animal turned out to the weather, as is evident in the case of cows that farmers sometimes allow to range all winter. It is however to be noticed, that proper exercise and exposure tends to increase an appetite, and thereby, if not in extreme, help fatten an animal. The state of the mind has an influence on the formation of fat.

153. In the sixth place, proper food being taken by a healthy body, the quantity should depend on the exposure to the cold.

As an animal depends for heat upon its food on the one hand, of course the amount of food should be proportionate to the heat to be produced. If a horse be provided with a blanket, he requires less food to keep him warm, because the blanket prevents the heat from passing away rapidly. A warm and protective stable has a like effect. So will it be with other animals. Cows which are "kept at the stack," that is, out of doors, eat all winter very heartily, yet do not better their condition; for all they can eat is used in their bodies to produce heat required the whole while. It is wise, therefore, to shelter animals. In this connection it may also be noticed, that the natural heat of some animals is much greater than that of others, and of course those animals of the highest natural temperature, require the most food. Thus fishes, which are naturally of a low temperature, require but little food to produce heat, and if much food of a heat-producing tendency be given them, they will become fat, for they cannot use it for any other purpose. Fish therefore are the most easily fattened of any animals. Taking into consideration what was said in a former paragraph, it will be evident that fish are the most profitable animals that can be raised, and the reason is also seen why there should be such multitudes of fish, viz., they require but very little food,

comparatively speaking. The water in which they live is nearly of the same weight as the fish; it therefore supports them without effort on their part—they are not a restless animal, and when they do move, it is with slight effort; they wear out their bodies but little therefore.*

154. In the seventh place, the quantity of food should depend upon how thoroughly the digestive organs separate the compound elements from the waste portion of the food.

This depends upon the nature of the food—for some kinds are much easier of thorough digestion than others—upon how the food is cooked, upon how thoroughly the food is chewed and mixed with the saliva, upon the nature and health of the digestive organs, upon the nature and health of the nervous system, and upon the mind. Why the digestive organs of one person should refuse to act thoroughly upon a kind of food very easily digested by another, is not known; but such is the fact. When the digestive organs are diseased, they will digest some articles readily, which they abhor when healthy. That these things depend much upon the mind and nervous system, is evident from various facts. Said a friend, when riding past some quarrelsome animals which were also very lean, "they have such dispositions they can never become fat." It is so with man. It may be considered almost a certain thing, that a fat person is pretty good-natured, and has not a very active mind. A constantly active mind, especially a fretted disposition, does not allow the stomach to receive, for a sufficient length of time, those nervous influences necessary for a perfect digestion of food. Active mental and physical exercise, with a diminished supply of food, will soon show their effects on most persons. Yet there are certain persons so constituted,

* There is but little outlay in preparing to keep them; a tub, barrel, or trough, with a very small stream of running water, or a mere hole dug in the ground, will be sufficient for a colony of fish of the most delicious flavor, and the scraps from a poor man's table will all be profitably used by these animals, and returned almost pound for pound. Fish will be much more profitable than swine, the meat being more wholesome and more cheaply obtained. In any city supplied with running water, young fish might be kept by a family with scarcely any expense, and fattened and grown till they would furnish a good repast for the table. It is not necessary that the water should run constantly through where the fish are kept; it is sufficient that the water be changed once or twice per day, or once in two or three days, according to the size of the reservoir and the number of fish in it. It would seem to be a profitable undertaking for a person to raise fish for the city markets.

that circumstances in the slightest degree favorable will develop fat. Active mental exercise will also prevent the perfect digestion of that kind of food which is adapted to nourish the muscles; and not only do wrinkles, but a spareness of the muscles exhibit a careworn person.

155. In the eighth place, with the foregoing considerations in mind, the quantity of food should be governed by the appetite.

This should be satisfied, but not satiated. To know when the appetite is satisfied, the food should be eaten in accordance with the intentions of nature, viz., it should be thoroughly chewed and mixed with the saliva, then it will be slowly swallowed into the stomach and the appetite gradually suspended. But if the food be hurried into the stomach, it may be filled with food indigestible, perhaps, and all of which would not be needed even if it could be digested.

156. The cause of the sensation of hunger acts, of course, through the nervous system upon the mind. If, therefore, diseases produce a similar state in the nerves to that caused by some part or parts of the body when food is required, the sensation will be the same, but it will not be satisfied by eating food, as want of food is not the cause of the sensation. Thus, sometimes persons have what they call a "headache appetite," or "hungry headache," but in such cases food must not be eaten.

157. On the other hand, diseases may produce such a state of the nervous system that the wants of the body, in respect to food, cannot produce any sensation of hunger. In this case the appetite must be aroused by some means. *The natural causes which arouse the appetite are exercise and exposure to the cold.* Gentle exercise and slight exposure, for instance a short and easy ride in the open air, are to be first tried; if the effect is desirable, they are to be gradually increased. If they do not succeed, various medicines may be resorted to. But before exercise and exposure, and much more before medicines be tried, there must be great certainty that the system needs and is capable of enduring them.

In the spring of the year, for instance, and when confined to the house by various causes, there ought not to be a hearty appetite; and many a person has reproduced disease from which he was recovering, by not being sufficiently careful about taking exercise and making exposure to the cold. It is always best to err on the safe side, and it is

seen not to be so easy a thing to give good advice as might at first be supposed.

158. When a person first feels unwell or has been so but a very short time, there is one rule to be always observed. *If there be no appetite let no food be used till appetite occur*, even if it do not for days or weeks; but commencing with *total abstinence*, 24 hours will usually restore to health. At the same time take but *little* if any *exercise*, and clothe *warmly* if *compelled* to go out. If there be an appetite, but not strong, a *small quantity* of easily digested food *may* be taken; but usually it will be more judicious *not to eat any*. If there be a hearty, hankering appetite, when a person is unwell or sick, or when well if there be an appetite for evidently unwholesome things, chalk, clay, slate pencils, spruce gum, alcoholics, tobacco, &c., they ought to be utterly refused. They will only make a bad matter worse; the desire for them is produced by a wrong state of the nervous system, that produces these false appetites.

159. If an appetite be produced immediately after, or before active mental or physical exercise, it should be gratified sparingly.

The exercise which has been or is to be, will render the system unfit to digest a large quantity of food, though it may be required. Appetite is not apt to occur immediately after extraordinary exercise. A horse will not usually eat as soon as put in the stable after a hard drive; but he should not have food then, if he will eat it; neither ought man to eat food in a corresponding case. If appetite occur just before retiring to sleep, it should not be gratified, except the body has been a very long time without food, when of two evils, the least will usually arise from eating sparingly.

4th. *The Quality of Food.*

160. This may be first considered in respect to its temperature. In infancy, nature has intended the food should

be taken at nearly the temperature of the throat. Ninety-eight degrees may be considered as the healthful point.

If children are fed artificially, it is an extremely important thing to have the temperature regulated by some better criterion than the lips of a person whose sensations are affected by so many circumstances as act upon the most healthy. In every family a thermometer should be considered as a requisite, and food, viz., milk for a young child, should be warmed by setting the dish containing it in water, and never allowing it to rise in temperature above 98 degrees by the thermometer; for a dish of milk set directly upon the stove or coals, frequently will burn the milk at the sides or bottom of the dish, and often the milk is allowed even to boil. But heating milk above 100 degrees injures it by altering its nature to a degree. To giving a child food of an unnatural temperature, and pouring it into the mouth with a spoon, &c., so that it cannot be mingled with the saliva before it is swallowed, may be traced the cause of many fits, convulsions, and diseases which are met with in childhood, and which lay the foundation for disease in after life.

161. After the period of infancy, nature has evidently intended that the food should be used of a temperature more irregular; but yet she has given an instinct to animals to drink near to the spring in winter and far from it in summer. The food of animals is not a good conductor of heat, and produces, therefore, no powerful sensation when taken into the mouth, and being chewed is not cold when swallowed. In cold climates the drink of animals is necessarily cold, but in cold weather little drink is required, without an animal has been used unnaturally, and all experienced persons are aware that it will not be proper to allow animals, if tired, to drink cold water plentifully either in summer or winter. Iced water, cream, and desserts are fruitful sources of dyspepsia. It may therefore be argued, that food should not be taken either very cold or very warm, either in winter or summer.

162. Another argument in favor of the same idea may be advanced, viz., that very hot or cold articles act injuriously upon the teeth, and *what affects one part of the body injuriously, affects every other part in a similar manner.*

163. The effect of low temperatures will, however, vary in persons of different constitutions, as will be seen by noticing the effect of cold upon any part of the body. If the hands be thrust into cold water, or cold water be dashed upon any part of the body in health, or if the face

of a healthy person be exposed to the cold air, a glow or flush will be produced, by an increase of the circulation of blood through the part, that it may be kept warm. If a person be very feeble, the glow is not produced, because the system has not power to increase the circulation of blood. The same things occur in the stomach. If a person be sufficiently healthy, there will be an increased circulation of the blood about the stomach, and as the increased quantity of blood is required in the formation of gastric juice, the cold facilitates digestion. But when there is inflammation of any part of the body, for instance the brain, physicians are in the habit of applying cold continuously, for instance a bladder of ice, for the purpose of lessening the circulation. Thus will it be with the stomach, even of the most healthy; the application of cold continuously will diminish the circulation, and retard digestion, and Dr. Beaumont testifies that he has noticed the process delayed for an entire hour, by the reception of a large quantity of cold water.

164. The injurious effect of cold upon the stomach will depend upon the quantity of cold articles taken; upon the natural constitution—for some constitutions bear cold much better than others, and recover from its action quicker; upon the health of the person—for a feeble person cannot recover from the effects of cold as the same person could if well; upon the age of the individual—for infants and elderly people cannot bear cold as those in the prime of life; and upon the exhaustion of the system—for when the system is exhausted, either by labor, by exposure to heat or cold, by watching, or fasting, it cannot increase the circulation in any of its parts to a remarkable degree.

165. As cold articles taken into the stomach are warmed by the circulation of blood, and as muscular exercise increases the circulation in every part, it should always be used when any chill is felt at the stomach after taking any thing cold.

In brief, therefore, cold articles should not be taken into the stomach when the body, from any cause, is not well able to spare the heat for warming them. This will be determined by any chill felt in the region of the stomach, though it is well to exercise a sound judgment before

trying the experiment. It is not, therefore, wrong to take cold articles into the stomach because a person is "warm," but because he is exhausted. As the same cause that made the body warm has produced exhaustion, it has been usually noticed that cold articles taken when the body was warm produced harm. If, however, the same exhaustion should exist when a person was cold, it would be so much the worse; so that in fact it is better for a person to be warm when exhausted, and liable to drink or eat cold articles. If a man rest himself, or his animal, after exertions before taking cold articles, it is not to cool himself or the animal, but to rest the system, so that when the drink is taken the body will have power to warm it.

166. Cold water is therefore the best beverage for some; and for some, warm but unstimulating drinks, especially in winter, are better.

167. It is certain, on the other hand, that nature never intended hot food should be used by man.

For she has made it exceedingly unpleasant to receive it into the mouth, which, in many respects, is a very good outpost to warn of danger approaching the stomach, and though it may sometimes be a very good plan to assist in warming the body by the use of heat-giving articles of food, yet the continued use of them above the temperature of the body, has been often found by experience to weaken the digestive organs in a remarkable degree, preventing a healthy circulation of blood about the stomach, and of course the formation of a proper supply of gastric juice.

168. The quality of food may next be considered in respect to condiments.

Among these are reckoned salt, vinegar, mustard, spices, alcoholics, &c. Salt and vinegar, in small quantities, without doubt facilitate digestion. In the first place, being palatable; and in the next place, their components are needed by the system in the fulfilment of its duties. By habit some become accustomed to them in much too large quantities.

169. Spices, including mustard, in quite small quantities, give an agreeable flavor to the food, and quicken digestion by so acting upon the nerves of the stomach as to rouse the circulation. The natural exciters and relishers of food are, however, found in exercise in the open air, and while the use of spices in small quantities may arouse the stomach to its duties, when the mind has been absorbed in business, the ultimate effect

will be injurious, though not such as to make it worth while to be too particular; yet every one should be careful not to acquire the habit of using spices very freely. The same things might be said about the effects of alcoholics upon the stomach; but there are other effects produced by whatever contains alcohol, however disguised, that strictly prohibit its use under any name or in any quantity.

170. Food may next be considered in respect to its consistence.

Dr. Beaumont testifies, that food must be of a certain consistence before the digestive process will begin, and it is reasonable to believe it is so. Food, to be sure, is to pass into the liquid blood, but yet it is itself solid. Much liquid in the stomach would so dilute the gastric juice, that it could not well perform its office. Thirst is an entirely different sensation from hunger. Thirst exists when fluids are required, but hunger when food is needed. Fluids taken when there is no thirst, it would be easily believed, must in some way prove injurious, as it would be compelling the system to take care of that for which it had no use.

171. Dr. Beaumont testifies, that when food and fluids are taken together, the first effort of the stomach is to remove the fluid; if the system required fluids, which was signified by thirst, it was removed at once, but if the system did not require fluids, the removal was slow. Therefore many of those things often thought the best, especially in sickness, cannot be so; for instance, gruels, porridges, and the whole list of "slops." If it be asked why they are so generally allowed by the physician, the answer is, that when sick, the less a person eats, the better, and there is very little real food in water gruel, beef tea, toast coffee, &c.; yet a patient will be content, thinking he has eaten enough when he has taken a bowl of such articles. Thus his mind is satisfied, and he eats in fact but very little; and people understand the importance of abstinence so little, they will not be content without the semblance at least of eating something.

172. If food be needed, it will be better, therefore, to eat something of consistence, which will be well chewed before it is swallowed, and not to drink in connection therewith, except thirst exist.

173. In the next place, the quality of the food may be noticed, in respect to the time required for its digestion. That which digests the most quickly, if it supply the system

with the same amount of ingredients, would seem at least, under certain circumstances, to be more wholesome than other kinds.

All kinds properly prepared before taken into the mouth, and properly acted upon there, will be more easily digested than otherwise; the time required for digestion will also depend upon the requirement of the system for food; as, if the system do not require food, digestion will not take place at all, and if more food be taken than is required, even that amount which is required will not be quickly digested. It will also depend upon the health of the body.

174. That some food should not require cooking is not strange, for instance eggs. These are already prepared to form the various parts of an animal, and why should they need much further preparation before the reception of their ingredients in the bloodvessels? Indeed, cooking them much, changes them to such a degree that they are quite difficult of digestion. Raw eggs are therefore frequently recommended to a person whose digestive organs are feeble. Cabbage raw digests much easier than when boiled; probably because its pores become closed with the fatty substance in which it is cooked, and by the effects of heat. But why there should be so much difference in the time required for digesting various articles of food strongly resembling each other, and why in some cases food indigestible in health should be quickly digested in sickness, and why an article should be digested with difficulty by some persons, when generally it is considered wholesome, cannot be determined.

175. The following table from Dr. Beaumont, though not very instructive, as perhaps there would be few persons with constitutions precisely like that of Alexis St. Martin, and consequently few whose stomachs would require the same length of time for digesting food—perhaps for some articles longer, and for others shorter, than in his case; yet is curious, as showing the average time required for the digesting of certain articles by him. The time in his case varied much in different experiments; it depended upon his health, the requirement for food, the quantity eaten, the temperature of the article, the exhaustion of his body by exercise, upon whether he took vigorous or gentle exercise or slept immediately after eating; and upon whether he was in good humor or angry when or immediately after eating; and sometimes there would be a variation when it could not be accounted for.

TABLE,

EXHIBITING THE AVERAGE TIME OF DIGESTION OF CERTAIN ARTICLES OF DIET.

Articles.	Preparation.	Time h. m.	Articles.	Preparation.	Time h. m.
Pigs' feet, soused,	Boiled,	1	Soup, chicken, . .	Boiled,	3
Rice, ...	Boiled,	1	Pork steak, . .	Broiled,	3 15
Tripe, soused, . .	Boiled,	1	Pork, recently salted,	Broiled,	3 15
Apples, sweet, .	Raw,	1 30	Oysters, fresh, . .	Roasted,	3 15
Trout, salmon, fresh,	Boiled,	1 30	Mutton, fresh, . .	Roasted,	3 15
———,	Fried,	1 30	Bread, corn, . .	Baked,	3 15
Venison steak, .	Broiled,	1 35	Carrot, orange, .	Boiled,	3 15
Sago, ...	Boiled,	1 45	Beef, with mustard,	Boiled,	3 15
Apples, sour, mellow,	Raw,	2	Sausage, . . .	Broiled,	3 15
Cabbage & vinegar,	Raw,	2	Beef, fresh, lean, dry,	Roasted,	3 30
Codfish, cured, dry,	Boiled,	2	Bread, wheat, fresh,	Baked,	3 30
Eggs, fresh, . .	Raw,	2	Butter, ...	Melted,	3 30
Liver, beef's, fresh,	Broiled,	2	Catfish, ...	Fried,	3 30
Milk, ...	Boiled,	2	Cheese, old, strong,	Raw,	3 30
Tapioca, . . .	Boiled,	2	Eggs, fresh, .	Boiled hard,	3 30
Milk, ...	Raw,	2 15			
Turkey, wild, . .	Roasted,	2 18	———, . .	Fried,	3 30
———, domesticated,	Boiled,	2 25	Flounder, fresh, .	Fried,	3 30
			Oysters, fresh, . .	Stewed,	3 30
———, .	Roasted,	2 30	Potatoes, Irish, .	Boiled,	3 30
Potatoes, Irish, . .	Baked,	2 30	Soup, mutton, . .	Boiled,	3 30
Pig, ...	Roasted,	2 30	Soup, oyster, . .	Boiled,	3 30
Parsnips, ...	Boiled,	2 30	Turnips, flat, . .	Boiled,	3 30
Meat hashed with vegetables,	Warm'd,	2 30	Beef, fresh, lean, with salt only,	Boiled,	3 36
Lamb, fresh, . .	Broiled,	2 30	Corn, green, & beans,	Boiled,	3 45
Goose, ...	Roasted,	2 30	Beets, ...	Boiled,	3 45
Cake, sponge, . .	Baked,	2 30	Beef, fresh, lean, .	Fried,	4
Cabbage head, .	Raw,	2 30	Ducks, domesticated,	Roasted,	4
Beans, pod, . . .	Boiled,	2 30	Fowl, domestic, .	Boiled,	4
Chicken, full-grown.	Fricas'd,	2 45	———, . .	Roasted,	4
Custard, ...	Baked,	2 45	Salmon, salted, . .	Boiled,	4
Apples, sour, hard,	Raw,	2 50	Soup, beef, vegetables & bread,	Boiled,	4
Oysters, fresh, . .	Raw,	2 55			
Bass, striped, fresh,	Broiled,	3	Veal, fresh, . .	Broiled,	4
Beef, fresh, lean, rare,	Roasted,	3	Pork, recently salted.	Fried,	4 15
—— steak, . .	Broiled,	3	Beef, old hard, salted,	Boiled,	4 15
Corn cake, . . .	Baked,	3	Cabbage, . . .	Boiled,	4 30
Dumpling, apple,	Boiled,	3	Ducks, wild, . .	Roasted,	4 30
Eggs, fresh, . .	Boiled soft,	3	Suet, mutton, . .	Boiled,	4 30
		3	Veal, fresh, . . .	Fried,	4 30
Mutton, fresh . .	Broiled,	3	Pork, fat and lean,	Roasted,	5 15
———, . . .	Boiled,	3	Suet, beef, fresh,	Boiled,	5 30
Pork, recently salted,	Boiled,	3			

176. In the next place, the quality of the food in respect to its adaptation to satisfy the wants of the system, may be noticed. The wants of the system are fourfold. From infancy to maturity it must be increased in size. It constantly wants material for its repairs; at times it requires material to fatten itself, and a supply of food as fuel is a want that is continuous, but more urgent at some times than at others.

The character of the food should, therefore, differ at different periods of life. To understand this fully, it should be remembered, as every day's experience testifies, that exercise tends to produce heat.

177. In infancy, therefore, food is required which shall cause the growth of the child, and also produce heat, and form fat.

For in the first place, the child, though small, has a great extent of surface in proportion to the weight of its body, therefore it must be supplied with a sufficient quantity of fat to prevent the rapid passage of heat from its body. Hence why, before infants are old enough to exercise, they are so fat, and of course, as the child is growing the fat must also grow. There are additional reasons, hereafter to be given, for the fat so conspicuous in young children. Too great a supply of fat makes the child too heavy, and by its weight tends to cause deformity. There must, therefore, be a very accurate adjustment between the quality and quantity of food productive of fat and the wants of the child.

177. Milk has been furnished as the food of young animals; it therefore must contain, for all the works of nature are perfect, the ingredients required by the system in the production of fat.

What part of the milk is chiefly adapted to this purpose seems to be indicated by one fact, viz., it is quite impossible to fatten animals on skimmed milk, or buttermilk; they will, however, grow well in other respects. The butter which has been removed, or something to take the place, is essential for fattening animals. This is also indicated by the fact, that the milk of the human species contains more butter than the milk of any other animals, and so it should be; as every other animal when young, has more of external protection than infants, it, therefore, requires more of the internal protection, viz., the fat. When,

therefore, an infant cannot receive its most natural food, that is advised which is most similar.* Asses' milk first, goats' milk next, cows' milk next. When this last is used, its quality will be improved by allowing it to stand for a short time, not till any cream can be observed on the surface, but till the upper part of the milk has become a little richer than the lower part. The upper half or two-thirds may then be carefully dipped off for use.

178. Another fact would show that sugar is well adapted to fatten the system.

For by using it in considerable quantities, all kinds of animals, the dog, the horse, the cow, will speedily become very fat. Children are especially fond of sugar and sweet articles, and in the milk of the human species sugar is more abundant than in case of any other animal. When it is necessary to give cows' milk to an infant, it is usual and proper to add a small quantity of refined sugar.

179. The food of the child should gradually change in its character, as it begins to take exercise.

This is what occurs in the natural food of the child. The appearance of teeth, signifies that there is need for their use upon food requiring to be chewed. But as the teeth, upon first appearance, are not adapted to chew hard food, such articles as bread and milk are indicated, while as the grinding teeth and wants of the child develop themselves, at the same time harder food and meat diet is indicated. The appetite changes in corresponding degrees.

180. *Nature has therefore made the food she has designed a child to receive, perfect ; and nothing which man can contrive or prepare, can compare with it. Whatever comes from his hand must differ more or less from the requirements of the system.*

Producing either too much fat or too little, and though after a few months the food of the infant may be changed for the milk of the cow, milk, and milk only, should be used as the most perfect and wholesome diet, till the child has teeth. Till its teeth are fully developed and strong,

* I do not know that the milk of the swine has ever been analyzed, but the want of external covering would signify a near approach to the wants of the human species, and it might be inferred they would be satisfied by food of a similar character.

it should have a diet of bread and milk, and afterwards the appetite of the child, without the system is peculiarly constituted, will generally desire a vegetable diet, puddings, pies, bread, potatoes, &c., rather than meat, until maturer years.

181. By rigidly following such a course, not only will a parent do the best for the child, but save herself much trouble.

As the child will not cry for food it has never tasted. If sugar be given to the child it should be dissolved in its food, as then it will not acquire a taste for sugar, or know what it is when it sees it. Many things would of themselves do a child no harm in many instances, but they must not for once be given to a child, as thereby a taste is aroused which will not be easily satisfied. And as "ignorance is bliss" to the child, "'tis folly" for it "to be wise."

182. In after life, the quantity of fat should depend, and it does, on the exercise of a person.

For as exercise produces much heat, it is not necessary that it should be husbanded with much care. Ladies therefore, as a general thing, require more fat than gentlemen, and their food should not be of the same kind, and they are more apt to be fond of vegetables, fruit, pastry, &c.

183. In the fall and winter, different requirements exist from those of summer.

There are then different appetites, and nature supplies different food for man and animals. To animals, she supplies an abundance of starch; they find it in acorns, in potatoes, and in grains which ripen in the fall of the year; and some kinds of potatoes are worth much more to fatten animals than others; the same is true of grains, and when examined, it is found, that other things being equal, those kinds of food containing the most starch, fatten an animal the most rapidly.

184. Again, those kinds of food containing starch, fatten an animal quicker if they be boiled; and the reason of this seems to be that starch is in the form of kernels, composed of concentric layers like an onion. The external layer is cracked by the heat of boiling temperature, and the juices of the stomach can thus act on the internal parts of the starch kernels, many of which otherwise escape digestion in the stomach.

185. These things would settle, without a doubt, that starch is a

kind of food useful in producing fat, and it has already been shown that sugar and butter are useful for a similar purpose. The nuts eaten by squirrels and many other animals, furnish a supply of oil with which the squirrel makes itself very fat in the fall of the year. Man is also inclined to eat fatty food in the fall and winter, and fat abounds in the meat food eaten at such times.

186. It would seem therefore that sugar, starch, butter, oils and fats, must be very similar to each other, and so they are. Indeed, they are composed of precisely the same ingredients, viz., oxygen, hydrogen, and carbon, the proportions of the ingredients differing in the different articles.

The fat of the body can, therefore, be very easily formed from any of the substances mentioned. Gum is of a similar character, so also is gelatine or animal jelly. Many animals eat gum and grow fat, and it is often recommended by the physician for the sick person. Alcohol is also composed of carbon, hydrogen, and oxygen, and when digested in the stomach, is capable of producing fat, as sometimes seen in beer drinkers, and in olden times, in case of those who, on recovering from sickness, were ordered to use large quantities of brandy, &c., which did not cause intoxication, to the surprise of the patient, who saw himself growing fat, but not strong. Alcoholics will not usually be digested, and when they are, it is worthy of notice that they do not increase the strength of a person in the slightest degree, but form a soft unhealthy fat, not needed, but injurious, if for no other reason, because the system has spent its powers in preparing it unnecessarily.

187. When the active duties of life are past, and age advances, the powers of the system being enfeebled and incapable of producing heat abundantly, the heat produced must not be allowed to pass off.

The food must, of course, be such that fat can be formed from it, and in this respect, second childhood compares with the first. And do not the appetites change with declining years? And does not the fat accumulate? Thus every class of facts tend to show that the food is of different qualities, and that certain qualities of food are adapted to form fat, and that without these are taken, fat cannot be formed. Those who do not wish to be corpulent or fat, are not under the necessity of being so: true, they may become so much easier than others. But did any one

ever know a tiger to be fat, or any animal to grow fat when fed upon lean meat, or skimmed milk or buttermilk? In rare cases, and under very favorable circumstances, an animal might become quite fat by means of the sugar contained in skimmed milk and buttermilk, but usually there will be a use for this besides for forming fat.

188. Active exercise would seem also to prevent a tendency to the formation of fat, while on the other hand indolence, eating sugar, gum, starch and fat, will, with good health and a cheerful disposition, tend in most constitutions to produce fat.

189. The next question to be settled is, that the food adapted to produce fat, is also adapted to produce heat.

In proof of this it may be noticed, that bees lay up a store of honey for use during the winter. The use to which it is put is evidently to keep them properly warm, for if the winter be very long or very cold, more honey is used, and the instant the honey of a swarm is exhausted, it dies. Housing bees in a warm place (it must not be too warm) "saves the honey." A thermometer placed in a swarm of bees, will show that it is warm. As the bees do not take exercise during the winter, there cannot be other use for the honey than to produce heat. Honey is of the same class as sugar.

190. The fat stored by the squirrel and bear, being gradually exhausted while they are quiet in their winter quarters, indicates that fats, oils, &c., are used to keep the body warm.

191. Cows and other animals turned out of doors in cold weather will not become fat, nor give a good supply of milk yielding butter, but grow lean; which shows that starchy and gummy food, which under some circumstances would be used to fatten and form butter, are necessary, and used to keep the animal warm.

192. Again, those very periods of life which require that the system should be protected from the loss of heat, are those periods when heat, to as great a degree as possible, should be produced.

Therefore, there should be a demand at such periods for food adapted to warm the system. But it has been seen that there is a special demand at such periods only for food adapted to fatten the system; from

which it would follow, that the food to warm and the food to fatten were the same.*

193. In summer there is comparatively little need of food to warm the system, and no need of food to fatten the system. Only a small quantity of the kinds of food above indicated should then be eaten.

Fevers which prevail in summer, are mostly found among those who by hard labor produce a hearty appetite, to satisfy which they eat a large quantity of food ill adapted to the purpose. They require a large quantity of food, but of a proper quality. Farmers have learned by experience, that buttermilk and skimmed milk are better adapted to their wants in haying and harvest time, than new milk, containing of course an amount of butter.

194. A person sick in a warm room, in summer or winter, of course would require but little heat-producing food.

For there is little need that heat be produced, and there is a stock or store of fat which has been prepared for use, and which may be used with little effort on the part of the system.

195. In the fall there is requirement for an increased quantity of food, both to fatten the system and keep it warm.

As the fat is deposited somewhat in proportion to the exposure of the system, it will not be best to put on winter clothing too early in the year; for as the coat of a horse "thickens up" when his blanket is left off till late, so will the fat be increased as an internal coat.

196. Attention may now be given to the qualities of the food, adapting it to answer the wants of the system in respect to its growth and repair.

It must be evident, that food adapted to promote the growth of the body, must be adapted to its repair. There are, however, several things to be considered. It is not certain how frequently some parts undergo a change—it cannot be very frequently—and therefore, once formed, but

* The question may arise—Are the sugar, starch, gum, &c., changed into fat by the digestive action of the stomach, or can the system make use of sugar to produce heat? Of course they are changed into fat when they are used to fatten the system, and they probably are when used for the purpose of warming the body; but the matter is unknown.

little food would be required on their account; while growing, their demands would be greater.

197. Some of the simple elements exist in the body in very small quantity, but yet they are requisite, and must be eaten—in how large quantities and how frequently, will depend upon whether they assist to form a part of the body which changes frequently or unfrequently; and whether substance which has formed one part of the body, can afterwards assist in forming another part.

198. The constituents of the body being so numerous, and undergoing a change more or less frequently, may account for an important fact, viz., that it is necessary for man and animals to eat a variety of articles.

Some may be the chief and most important ones, but others must be taken more or less frequently; dogs fed for some weeks on one kind of food, pine away and die—and one German physician fell a victim to the cause of science, by trying the experiment of living upon one kind of food for a long time.

199. It is a difficult thing to point out all those articles which are profitable or necessary to nourish the body.

But as animals grow when fed on skimmed or buttermilk; and as the young chick is formed from the egg, and as the tiger living upon lean meat is strong, and as fish fed upon lean meat grow very fast, but are lean—it may be inferred that milk, eggs, and the lean meat of beasts, birds, or fishes is well adapted to strengthen the body and to cause it to grow; but it is also seen that certain animals living upon fruits, and other animals living upon grasses, grains, or roots, are also strong and grow rapidly when young. Upon farther examination it has been found, that the same kinds of compound elements exist in these articles of food as are found in meat, eggs, or milk. In some of the grains they exist more abundantly than in others. The same is true of the grasses or other articles of food used as nourishment by animals.

200. In every organ and every part of any organ of the body, more or less nitrogen will be found. Whatever, therefore, is used for the purpose of forming any part of the body, must contain nitrogen.*

* Some, however, have contended that nitrogen could be, and was, obtained from the air. Of this, however, there is at present no proof.

Some have therefore laid it down as a rule that the more nitrogen any article of food contains, the more nourishing would it be ; and upon this principle, tables have been formed showing the comparative qualities of different kinds of food, but they have not been found very satisfactory.

201. If we subtract fat, sugar, starch, and gum from the articles usually set upon the table, the remainder will consist mostly, or entirely, of nourishment and waste food, the amount of which last will depend upon the quality of food and the thoroughness of digestion. Of the amount of it each person must judge for himself, after considering the duties of the second stomach.

202. In infancy, when the child is growing, and when, a little older, it begins to exercise, milk is kindly provided for the wants of the child, in respect to nourishment. Why, then, should such food as arrow-root, or any of that class of food designated by the name of pap, be used ; since, not containing a sufficient amount of nourishment, the bones of the child cannot become strong, the ligaments cannot fulfil their duties, and deformities will be produced, as well as bad teeth, and other evils too numerous to mention, all of which might be avoided by the use of nature's diet ?

203. Because milk is so perfectly adapted for infancy, it would not be probable that it would be the best diet, if used exclusively in youth, or even childhood, much less in manhood.

The active exercise of the system calls for different food, and it must be taken freely ; while on the other hand, in old age the infirmities of the system render it impossible to take exercise, and nourishment is required in only very small quantities.

204. The food supplied to man in warm climates, the effect of heat upon his feelings, and the exhaustion of the system produced by heat, all signify that exercise should not be laborious in hot weather, or in warm climates.

Of course, if but little exercise be taken, the quantity of nourishing food should correspond. On the other hand, in winter, and in cold climates, the food supplied for man, the energy of his feelings, and the active state of the digestive organs, signify that man should take vigorous

exercise, which is also of advantage in assisting to keep him warm, and of course, he should then take an abundance of nourishing food, to which he will be induced by his appetite.

205. In warm weather, therefore, very little food should be used, either to nourish, warm, or fatten the system, and the same is true in cold weather, if a person be not exposed to cold; for instance, if he be a sedentary person, or an invalid; while in cold weather a plenty of food is required by an exposed person, to nourish, to fatten, and to warm the body.

206. *In the fifth place*, we may consider the effects of habit upon the digestive organs.

This is very great. A tendency to what is called periodicity, is one of the most noticeable things in the system. Diseases of many kinds grow worse and better at stated intervals, and many things which take place in a healthy state of the system occur once in a certain time, and the longer the time during which this has been, the more certain is the occurrence at the given time. A person who is in the habit of waking at a certain hour never fails of the time. If food be taken at regular intervals, the stomach in a short time becomes habituated, and is prepared at the time of eating, to digest food if it be at all required.

207. It is very important that it be so, and the habit which some persons have of changing the hour of their meals on one or two days of the week, is very bad. Much better is it to go without a repast and eat more heartily at the next, prepared at the usual hour.

208. *In the sixth place*, we may consider at what times food should be eaten. Upon this point much has been said, and it need not be repeated. But it may be further remarked, that food should be taken at a short time after rising in the morning, a little while being allowed for exercise. The time of the next repast will depend upon the labor the person performs. Three times per day is as often as it is well for *any* person to eat. A professional, or a sedentary person, will usually be better with two repasts.

209. If three repasts are taken, the second should be

eaten about the middle of the day, and the last at five or six in the afternoon.

A lunch should not be taken, as it will require from two to four hours for an ordinary repast to digest, after which a few hours' rest is required by the stomach. If a lunch be taken about 11, in the midst of its digestion dinner is eaten, and it prevents the digestion of the lunch, which also prevents the digestion of the dinner.

210. If two repasts be taken, dinner should be taken about three or four o'clock in the day, and without being preceded by a lunch.

It seems better thus, because then a heartier repast will be eaten, and the stomach more filled; and when the stomach is quite well filled, its muscles can operate on its contents to better advantage. It is not well, therefore, to eat little and eat often.

211. It is usually thought that infants should eat oftener than mature persons, and there does not seem to be any objection to this opinion, if it be not carried to the extreme. An infant does not take much exercise, and is thoughtless, and if it be not sick, or fretted by being made uncomfortable, its system has nothing upon which to bestow its powers, except its own nourishment. It may therefore, without difficulty, be engaged in digesting food much of the time. But the stomach should have time to rest. When quite young, therefore, to eat five times per day would seem to be enough, and four times would perhaps be better. After a child has a little age it should eat but four times per day.

212. Whether it eat oftener or less frequently, it should eat at *certain times and at regular intervals*, and it will be of universal application, that the youngest child *should not eat during the night*, which should be spent by it in sound sleep.

A little trouble and time will be required to form good habits in the child, but they well repay the care.

213. *Drink*. Before considering the changes the food undergoes in the stomach, it may be well to treat upon drink. The use which water is to fulfil in the body, does not require that it undergo any change.

It is received into the stomach, therefore, merely as into a conven-

ient place from which it may quickly pass into the bloodvessels if needed.

214. Its need is signified by the sensation of thirst.

This does not ever seem to be wanting when drink is required; it may be however. It frequently exists when there is no need for drink, for this may be swallowed hastily, and the stomach filled with water without quenching thirst. If, however, the mouth and throat be rinsed with water by a person who is very thirsty, and then water drank slowly, the thirst will be satisfied when a proper quantity of drink has been taken.

215. The bad effects of drinking too much are manifold. Dr. Beaumont testifies that when drink is required, it will immediately vanish from the stomach, passing into the bloodvessels of that organ, and thence into all parts of the body. He also testifies that if too much drink be taken, it will remain in the stomach, preventing the digestion of the food. Farmers in summer frequently complain of being what they call "water-logged," and say that they can feel the accumulated water move in their stomachs. The veins of such persons appear, and are, full.

216. As the drink passes into the bloodvessels till they become filled, when an additional quantity will only be productive of harm, thirst should not be gratified if it exist when the bloodvessels appear full.

The sensation of thirst is then produced by some unhealthy state of some part or parts of the nervous system.

217. If the bloodvessels do not appear full and thirst exist, it should always be satisfied, in sickness or in health.

Water requiring no change, its use will not cause any exhaustion of the powers of the body. It may be taken at or between repasts, for if needed, it is at once removed from the stomach, and does not retard digestion; but if it be taken to "wash down the food," or because the beverage, tea, coffee, &c., is relished, it proves very harmful, in a short time entirely deranging the powers of the system.

218. The temperature of drinks should be the same as the temperature of food.

A very important inference may be drawn from what has just been said, viz., that taking drinks when a person is necessarily exposed to any contagious cause of disease, is desirable. For if the bloodvessels

be filled with drink from the stomach, they cannot so readily receive any thing through other parts of the body. Upon going into a sick chamber when there is any danger, or before going out in the morning in a section of country where there is any cause of disease suspected in the air, it will be proper to drink such a quantity of fluid as will fill the vessels, which during the night have lost a part of their contents. If a person have been bitten or acted upon by any poison, drinking freely of water may fill the vessels and prevent the poison from passing into the bloodvessels as it otherwise would.

219. It will also be inferred, that the quantity of drink a person can swallow is not a measure of the capacity of the stomach, and that a person could drink much more at one time than at another.

220. Most fluids are composed for the most part of water; some of the other ingredients of fluids are digested, and some pass through the stomach into the second stomach, and some pass into the bloodvessels without undergoing any change.

221. If fluids be used, but not in large quantities, when not required, they will remain in the stomach till the bloodvessels can receive them. If they be used still more freely, they will be allowed to pass on into the second stomach, and produce the apparent effect of a cathartic. If they be used in so large quantities as to fill the stomach, they will cause vomiting.

A free use of fluids, therefore, tends to keep the bowels open, but at the expense of healthy digestion. As an emetic, there is nothing, perhaps, which can be so highly recommended as simple water, if the object be merely to evacuate the stomach. It should be drank hastily and till vomiting occur. One pint may be sufficient, or it may require three quarts, but except a person be poisoned it is judged to be sure in case of every person, and in most cases of poisoning. It acts more easily than any thing else, not being apt to cause retching, and is not unpleasant to take. If the water be warm it acts more quickly, and its action takes place more speedily if the throat be acted upon by a feather or the finger. Warm water is more apt to make a person feel sick, but the water should not be quite cold, as such a quantity of cold substance would be likely to produce a chill.

222. It should also be remembered, that when a physi-

cian gives an emetic, he has frequently other objects in view besides emptying the stomach. Water, perhaps, would not then be the best thing.

223. Water used in large quantities also tends to increase the action of all those organs by which watery substance is passed from the system.

For as the bloodvessels become too full for their good, nature endeavors to lessen their contents by causing the skin to perspire, the lungs to pass off more moisture, &c. Hence a person who wishes to sweat, drinks freely to assist.

224. From what has been said, it will be seen that the first effort made in the stomach will have for its aim to remove the superabundant fluid. The first process in the digestion of milk, for example, is the curdling of it; the second is the removal of the whey, or the watery portion, more strictly speaking.

When curdled milk is "thrown up," therefore, it signifies not that the digestion is unhealthy, but that too much food has been taken.*

225. After food has been reduced to about the consistence of a paste, it is mixed with the gastric juice, and begins to change to a grayish color; little by little it becomes of a uniform consistence, like that of soft paste, is called chyme, and passes on into the second stomach.

226. Certain substances, either from their nature or their quantity, cannot undergo this change; but they must not be allowed to remain in the stomach, as the room will be required for wholesome food. Sometimes they are removed by the passage into the second stomach; sometimes they are sent back through the œsophagus. Each operation takes place under the influence of the nervous system, and of course, the perfection with which it takes place, depends upon the health of the nervous system.

227. This is especially worthy of notice in respect to the action of certain poisons which ought to be evacuated from the stomach, but

* Many a child has doubtless received medicine to prevent milk from curdling and "becoming so hard" upon its stomach.

which are not; for instance, if a person have taken opium, laudanum, or any thing which stupefies, he not only is too insensible to swallow an emetic, but it would not usually operate if he did. Cold applications are first to be made to his head, and warm applications to his feet, and rubbing tried till his senses recover a little, when medicine may operate.

228. It may be useful to notice, in this connection, that common mustard will be a very active emetic.

It can be readily had in almost any case of poisoning; where it cannot, water should be drank as before mentioned. The mustard sold at the shops is too often impure. If unground it should be bruised before it is taken, and used in any way most desirable for the person to swallow it in the quantity of a table-spoonful, if so much be necessary. There will be no danger of taking too much, but there may be of taking too little.

229. If any acid, ley, or the like, have been swallowed, cold water should be taken as quickly as possible, and in large quantities. If any poisonous substance, not a liquid, have been taken, some kind of thin paste, as of flour and water, or the like, should be used before the emetic. The object is to cause the poison to be taken off from the sides of the stomach by the paste. In such cases, also, a series of emetics preceded by gruel-like paste should be used, that there may be a certainty that the poison has been entirely evacuated.

230. There are three things to be kept in mind therefore, if a person be poisoned. 1st. To prevent the poison from acting on the stomach, either by diluting it as in case of acids, &c., by drinking largely of water, or by altering it, as when eggs are used to change corrosive sublimate (the most common of bed-bug poisons). 2d. To remove it from the stomach by vomiting, or if a person continue stupid, by a stomach pump. 3d. To counteract the effects of the poison, which are in the first place stupor, which a person may combat by cold applications to the head, warmth to the feet, exercise, such as walking the person about, and rubbing; in the second place inflammation, which will require attention for a long time in many cases, and is, if curable, of such nature, that delay till a physician can be called will not be hazardous, as it will be if a person have become insensible.

SECTION 3.—*The Second Stomach, Liver, Pancreas, Spleen, Colon, &c.*

231. The second stomach is a long tube, like the stomach composed of a museular coat, an external eovering called the peritoneal coat, and a lining called the villous, but usually the mueous coat or membrane. Between the muscular, and outer and inner coats of the stomaeh, are thin layers of cellular substance.

232. A common name for the second stomach is the small intestines, and the tube is divided into three parts, the first, upper or nearest to the stomach portion, from 9 to 12 inches in length, is called the duodenum. It is a little larger than the other parts, which equally divide the remainder of the tube; the first of these is called the jejunum, from being usually empty, the remaining, or lowest, or last half, is called the ileum.

233. The whole length of the canal may, however, be considered as one organ. It is situated in the abdomen, and is subject to the same effects of pressure as the stomach, and it is modified precisely as in case of the stomach.

234. The second stomach commences at the pylorus, and passing upward and backward a very short distance, it turns downward, but almost immediately bends again, and passes almost to the left side of the body (Fig. 95). It then comes a little forward, and is found just within the muscles of the sides of the abdomen, where it begins to pass up and down, and also to find its way to the right side, as seen in Lith. Pl. 3, Fig. 1; it then takes a back course to the left side, to again eome back and terminate in the colon, which commences in the right and bottom part of the abdomen (Pl. 3, Fig. 1).

235. The upper, straight, or duodenal part of the second stomach, is somewhat closely confined to a single position, but the remaining portions are retained in their positions by a wide ribbon-like appendage, ealled the mesentery, which allows of great extent of motion in any direction (Fig. 96).

Fig. 95.

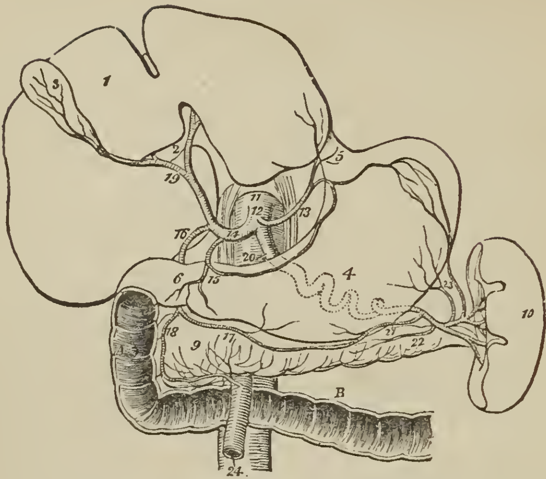


Fig. 95.—1, Liver turned up and laid back. 2, Fissure in the under surface of the liver. 3, Gall bladder. 4, Stomach. 5, Lower portion of œsophagus. 6, Pylorus. 7, Head of pancreas. 22, Small extremity of pancreas. 10, Spleen. 13 to 24, Blood-vessels. A, Opening of the ducts from the pancreas, liver, and gall bladder. B, Duodenum open, that the folds of its internal surface may be seen.

236. The structure, as observed, is similar to that of the stomach, the external coat is a part of the same as on the stomach (Fig. 96). The muscular coat is composed of two layers ; one consists of circular fibres, more or less near to each other, as the case may be ; the other consists of fibres, which extending in the direction of the length of the intestine, shorten it when they contract ; the circular fibres, by contraction, lessen its diameter or close it.

237. The mucous coat is much like that of the stomach, but is arranged in the form of little folds (Fig. 95), or plaits, by which a greater extent of surface is gained. It contains many follicles, cryptæ, or simple glands, from the tiny mouths of which a constant flow of substance takes place to lubricate the canal.

Fig. 96.

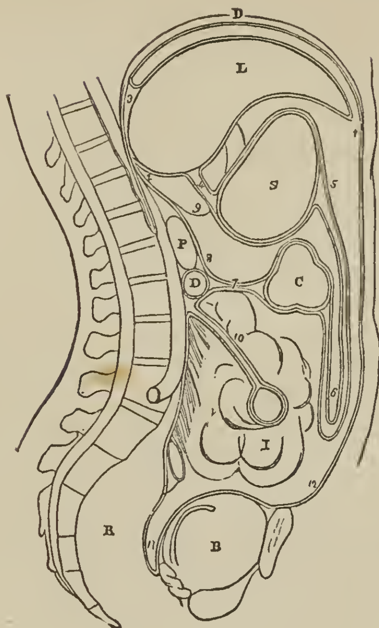


Fig. 96.—Represents a section of the middle portion of the abdomen. The organs are somewhat displaced and disproportioned, the chief object being to exhibit the peritoneal coat. Commencing at 1, it can be traced up under and lining D, the diaphragm from which it is "reflected" at 3, to the liver L, over the front edge of which it can be followed, and under the liver to 4, where it turns on to the stomach, and at 5, passes down in front of the abdominal organs to a greater or less distance, when it turns upward, forming a kind of apron, commonly called the caul, a beautiful thin membrane in appearance, netted over with fat, being the part butchers put upon the front quarters of veal to give a better appearance, as the fat caul from a good animal can be made to improve the appearance of an indifferent one. It can be traced to the colon C, one part of which it covers, and then leaves it to go to the back-bone, touching upon and partly covering the duodenum D, when again it comes away for some distance to form the outer coat of the small intestine; the general outline of its convolutions being shown by I. The peritoneal coat can then be followed back to the the spinal column, the two layers adhering at 10, forming the ribbon-like part, called the mesentery, between tho two thicknesses of which the bloodvessels, the nerves, the lacteals, and the glands of the intestine are found. After continuing in a similar manner about the entire length of the second stomach, it follows down to 11, turns over the vessicle B, and passes up from 12 to 1, lining the walls of the abdomen, being there commonly called the film. The peritoneal coat or peritoneum adheres or grows to, or rather is a part of those organs upon which it is found; the surface opposite to that which adheres, being "free," viz., not adherent to any thing, but continually moistened with a very glairy fluid. In general appearance, the peritoneum is a light pearl-colored, dense, strong membrane, rather easily torn off from the parts to which it belongs. If attention be

To keep the muscles in action, and to supply this substance, the second stomach must be furnished plentifully with bloodvessels; and must receive nervous influence, and be acted upon, indirectly at least, by the mind.

238. Firm substances, like small lumps or kernels, and called glands, are found in the sides of the second stomach. Their use or intimate structure has not yet been ascertained, and they are not probably rightly called.

239. The diameter of the second stomach varies in its different parts, and very much in different individuals. Its length is more variable than its diameter, especially in different species of animals.

In the animals which feed upon grasses and food containing much waste substance, the second stomach is very long—in the sheep, from twenty-five to thirty-five times the length of its body. In animals like the tiger, living upon a meat diet, it is short—in his case being only three times the length of his body. In man, it is intermediate—sometimes as short as five feet, but usually from sixteen to twenty-five feet; though sometimes as long as thirty-one feet.

240. In animals which change the character of their food and their habits at certain stages of their existence; as, for instance, in some of the frog species, the length of the second stomach varies accordingly—in the tadpole being very long, signifying that the animal lives upon vegetable

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again bestowed upon the figure, what appears another membrane, will be seen at 2, which passing down covers one part of the stomach, adhering at 4, to the peritoneum previously traced, and also at 5, from which it follows down, forming part of the caul, the two layers adhering to each other. It can then be traced up to the transverse colon; the surfaces between which 6 is placed, not adhering, but are moistened by serous fluid. It forms the outer coat of the upper part of the colon, adhering to its companion between the colon and D, the upper part of which it covers when passing over the pancreas, it is found at 2 again. [Thus all the organs of the abdomen may move upon each other without the slightest degree of friction. The reader must not gain an idea that there are any spaces between the organs. They are in close contact, unless separated by collections of water in case of dropsy, which, from the great extent of surface, may be very great in quantity in a short time. Just beneath the free surface of the peritoneum a beautiful network of bloodvessels is found, the number of which is almost infinite, whence inflammation of the peritoneum is apt to be very serious, and must not be trifled with. The healthful fulfilment of its duties requires also the action of nervous influence, and as the action of the nervous influence as well as the structure should be and is similar in the whole extent of the peritoneum, disease of any part very quickly extends under the slightest aggravation. Though slightly irregular, attention may here be drawn, as the cut will enforce the idea, to the fact that the organs of the abdomen are composed of many different parts, differently constructed, and requiring nervous influence differing in its effects and degree; hence subject to different diseases and by a variety of causes, all which things exhibit, in a striking light, the danger of tampering with the laws of health, and the importance of the greatest discretion, learning, and experience on the part of an adviser when disease exists.]

diet, seeds, roots, &c.; while in the full-grown frog it is comparatively short, as he supports his life by using meat diet, bugs, worms, &c.

241. In the human species it will probably be found almost universal, that those persons who are fond of, and live upon meat chiefly, have short second stomachs; while those fond of breadstuffs, vegetables, and fruit, have longer second stomachs. It might be a question, whether the change of diet in case of man or animals, would tend to alter the length of the second stomach. It is said, and probably with truth, that the use of concentrated food tends to lessen the size of the first stomach.

242. The reason why this difference should exist in the length of the second stomach, will be evident if its use be considered, viz., in the first place, to cause the food to undergo a change; and in the second place, to remove the proper parts of the food into the bloodvessels.

The more waste substance found in the food, the longer should the food remain in the second stomach, and the greater must be its length; as while the food is in the second stomach, it is gradually moved along by the action of the muscular coats; if the food require to be acted upon for a long time, the tube through which it is passing, must be correspondingly large.

243. The food, which in the first stomach has passed through the first process of digestion, and been formed into chyme, passes into the second stomach through the pylorus; but undergoes no change till it has been mingled with three fluids,—the pancreatic juice, the bile, and the gall.

244. *The Pancreas*, in which the pancreatic juice is formed, has in the calf the name of "sweetbread." It is a gland (Fig. 95), in color, external surface, and internal structure, resembling the salivary glands. It is situated across the body in front of the back-bone, separated from it by large bloodvessels, having in front of itself the lower portion of the stomach when distended. It is from six to ten inches in length, weighing about four to six ounces. Its larger extremity, called the head, is toward the right, near where its tube or duct opens into the second stomach.

245. The fluid formed in it, is somewhat similar in general appearance to the saliva; but differs from it in chemical character.

The quantity of pancreatic juice formed, the diseases of the organ or its importance, are not known.

246. *The Liver*, in which the bile is formed, is the largest gland in the body. Its appearance, size, and density, are much like the liver of the hog. Its situation is in the abdomen, immediately beneath the diaphragm, as seen in Fig. 96, and in Fig. 97. It nearly fills the middle region of the right half of the body, and passes across the centre into the left half.

It therefore occupies more space than is usually thought. The position it occupies is constantly changing when the breath is drawn in and thrown out; as its upper surface is always in close contact with the diaphragm or midriff, and it, of course, is acted upon by all those causes of pressure and displacement which affect the stomach.

247. Its form is very peculiar. Above it is arching from all its borders, and below is concave from all its borders, but not in a degree to correspond with its convexity above. Its edges are, therefore, very thin, as shown in figures of its sections. In the centre of the right side it is very thick, but from that point to its extreme left, it diminishes in thickness, presenting a wedge-like form, except that its thickness is diminished from its under side.

248. It is held in its position by ligaments, called roots, which attach it to the back-bone, and by the "suction" of the chest. It is not connected with the diaphragm in the slightest degree, but merely lies against it.

249. It is composed, like other compound glands, in the first place, of a tube which divides into a great number of branches corresponding with the large size of the liver, the twigs of these branches terminating in clusters of cryptæ. The tube commences at the inner surface of the second

Fig. 97.

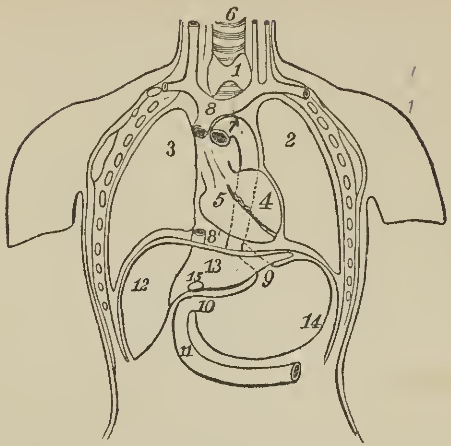


Fig. 97.—Section of the chest and upper part of the abdomen. 2, Left lung, perfectly filling the left side—see also Lith. Pl. 3, Fig. 1. 3, Right lung, somewhat broader and shorter than the left. 4, The left or back heart, cut across but not exhibiting its internal divisions. 5, Right or front heart. 7, Arch of the aorta, continued back of the heart, as seen by the dotted lines. 8, The vena cava descendens. 8′, The vena cava ascendens, viz., the veins through which the blood returns to the heart. 9. The opening of the œsophagus into the stomach—the dotted lines exhibiting the direction of the lower part of the œsophagus, behind the thin point of the liver. 10, The pylorus. Both this and the opening at 9, being closed when the stomach is distended with food, as here represented. 14, The larger curvature of the stomach, as from 9 to 10 is the lesser curvature. 11, The commencement of the second stomach, called the duodenum. 12, The larger lobe of the liver—indistinctly separated from the lesser lobe 13. 15, A section of the gall-bladder. The diaphragm is seen arching above the organs of the abdomen, as when the breath is thrown out. When the sides of the diaphragm are contracted and the sides of the abdomen relaxed, the parts below are pressed down while the air pressed in through the windpipe presses down the bottom of the lungs, causing it to follow the depression of the diaphragm, the movement of which is very slight beneath the heart. 1, Gives the form of what is called the thyroid gland, situated upon the windpipe 6, a little below the "Adam's apple." [It is of a red-purple color, softer than liver, somewhat saddle-shaped. It receives bloodvessels and nerves, but has no tube leading from it. Its use is not known; and though in external appearance somewhat representing some of the glands, it is in all probability wrongly named. It sometimes enlarges, producing what is called goitre, broncocele, swelled neck. One of the most important causes of this, is the use of hard water—as in passing through the entire United States, it has been noticed that very few cases of goitre are found in sections where the water is soft; but that they are very common in central New-York. and other sections where the water is hard. After attention had been arrested by the evident fact, it was also found to be the case in Europe; in some sections of which, the evil is much more extensive than here. Other causes may, and doubtless do, assist to produce the result.]

stomach, about three or four inches from the pylorus, and is lined by a continuation of the lining of the second stomach.

250. The liver is, of course, supplied with blood to form and repair itself not only, but also to form the bile. But upon examination, the liver is found to be supplied with two kinds of blood, which is not the case with any other part of the body except the lungs. One of these kinds is the same as every other part of the body receives; but by a singular arrangement, all the blood passing to the stomach, pancreas, second stomach, and spleen, and not used in them, passes directly to the liver through vessels that divide and subdivide in every part of it (Lith. Pl. 4, Fig. 4).

251. Some argue that the liver is nourished by the blood first mentioned, and the bile formed from the blood last spoken of, while some think that both kinds are necessary in the formation of bile. Those who think the bile is formed only from the blood coming from the stomach, &c., are of two classes. One class thinks there is some condition produced in the blood as it is circulating through the digestive organs, which renders it unhealthy, or unfit to go into other parts till it has been acted upon by the liver, and sustain their opinion by the fact, that when the liver is unhealthy and does not, as they think, purify the blood, the whole body is soon enfeebled and indicates symptoms of ill health. The other class thinks that the bile is of essential service in the second process of digestion, and that the reason why the blood from the stomach, &c., passes through the liver is, that the quantity of blood supplied to those organs is always increased before there is any cause for the formation of bile, to aid in the second process of digestion; that therefore, there is always an increased circulation of blood to the stomach, &c., before the liver requires an increased circulation, which it always now receives when needed, as increased circulation through the stomach necessarily causes, in health, an increased circulation through the liver.

252. Between the bloodvessels and tubes or ducts of the liver, and between the cryptæ, a dense substance is formed, called the parenchymateous substance of the liver, the whole is then covered with a membrane exceedingly glairy, its outer surface being kept moist by serous fluid.

253. The substance formed in the liver is called the

bile; it is almost as limpid as water, of an orange-green color, and rather sweetish than bitter.

It is not certain whether it be formed constantly, or only when necessary in the digestion of food, or is merely increased in quantity then; nor is it certain how much bile is formed in any given time. In some persons there seems to be much more formed than in others, and in the same person different quantities at different times.

254. *The Gall* is found in the gall bladder, or gall cyst, which is of a pyramidal form, and found underneath the liver, (Fig. 95), the base of it coming to the edge of the liver, as indicated in Lith. Pl. 3, Fig. 1; it is furnished with blood as other parts of the body. A tube, called the gall or cystic duct, leads up and back from it, and then downward to open into the tube called the hepatic duct, leading from the liver to the second stomach. The gall is an exceedingly bitter fluid, of a dark-green color, thick or ropy in consistence.

It passes down into the second stomach, as some believe, because it is a worthless substance, which ought to be cast from the system, and as others think, because it aids digestion.

255. Some believe that the gall is formed in the liver as bile, passes from the liver and through the branch tube into the gall bladder, where it receives its bitter and other gall qualities; while others think that the gall bladder is a great cryptæ, the inner surface of which forms the gall. And it would seem as if the gall bladder could as easily form the entire gall as add bitterness to bile.*

256. Before tracing the course of the bile in the second stomach, its action upon the first stomach, and its presence there may be considered. The distance from its entrance into the second stomach is so near the pylorus, that it would seem easy for the bile to find its way into the first stomach; but it is seldom found there, and it is doubtful whether it is ever of any assistance in the first process of digestion. Dr. Beaumont noticed it in the first stomach in but very few instances, when he could not decide against its utility.

* The common idea is, that bile is bitter, but if it were, liver would taste bitter when eaten, as the bile could not be entirely washed out. If the gall be allowed to run over meat it is spoiled.

257. Pressure upon the abdomen, especially forcible pressure over the region of the liver, will cause the gall and bile to flow into the second stomach, and thence backward into the first stomach.

Hence when a person vomits, the retchings would produce this effect, and it will be noticed that if bile or gall make its appearance, it will not be when the emetic first begins to act. The stomach, therefore, is not so "bilious" as people suppose. There may be bile in the stomach when vomiting begins, but it is not probable. Nor is the quantity ultimately removed to be judged by the *apparent* quantity, for a little gall will bitter and color a large quantity of fluid or other substance.*

258. The gray paste or chyme, differing in its consistence and qualities according to what it has been formed from, receives in the first part of its progress through the second stomach, the pancreatic juice, the bile and the gall; and mingled with these, it is slowly pressed on by the contraction of the muscular coats of the intestines. Thus acted upon, it begins to undergo a change; a larger or smaller portion exhibiting a color and consistence which varies from that of a thin gruel to a thick cream. Its name is chyle, the lacteal (milk-like) fluid, the white blood, &c. It contains those parts of the food destined to form the blood.

259. It is removed by a set of vessels called the lacteals, which commence in a manner which has as yet escaped scrutiny. They can be observed quite near to the inner surface of the second stomach, from whence they pass through the

* Another common error is, that whatever is thrown off from the stomach was there when the emetic was taken, and the necessity for the emetic is judged by the quantity removed. This is the case with certain kinds of emetics; for instance, water. But usually the first effect of an emetic is to cause the sides of the stomach to remove into it, from the blood circulating around the stomach, a quantity of fluid substance which is then, with any other contents of the stomach, thrown off. Emetic after emetic may be given, as has been done, till death is caused, and yet from the stomach something may be thrown off each time.*

* Diseases and peculiar conditions of the liver, will be spoken of when it is again treated upon as one of the class of excreting organs.

muscular coat, and are received between the two thicknesses of the mesentery, which (Fig. 96) stretch, ribbon-like, from the back-bone to the intestine. There are millions upon millions of these roots, which immediately begin to unite with each other, until at last they all terminate in a single tube or duct called the thoracic (chest) duct. There are many more roots of lacteals in the upper part of the small intestines than farther on, for the second process of digestion goes on more rapidly in the upper than in the lower part of the canal, and of course more chyle requires more lacteals to remove it. (Fig. 109, B).

260. In the course of the lacteals, there are small roundish or oblong-shaped organs (Fig. 98) called mesenteric or lacteal glands, but their intimate structure or particular use is not known. The chyle seems to change its color somewhat as it is passing through them, and they therefore produce some effect upon it.

Fig. 98.

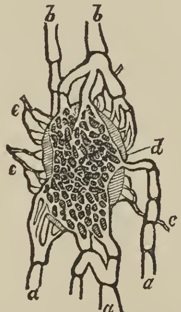


Fig. 98.—Lacteal gland, much magnified. *a*, *a*, *a*, Vessels opening into it. *b*, *b*, Vessels leading out from the gland. *d*, Parenchymatous substance of the gland. *e*, *e*, *e*, Bloodvessels leading to and from the gland.

261. The thoracic duct commences just below the diaphragm, by the pressure of which it appears to be enlarged. Above the diaphragm, it passes up in front of the back-bone,

and rather upon its right side, till it arrives at the centre of the back, when it winds across to the left side of the centre upon which it is situated, till it arrives in the region of the neck, where it turns forward, and bending downward, empties its contents into the vein at the angle where the vein from the left arm unites with the left jugular vein. Its size is small, not being as large as a common quill, but it is a canal of much consequence.

Why it should pass such a distance before emptying itself, is yet a mystery; without a doubt, some excellent purpose is served.

262. That portion of the chyme, bile, gall, pancreatic juice, &c., which has not undergone the change, passes through the entire length of the second stomach, into the large intestine, which commences (Lith. Pl. 3, Fig. 1), in the lower and right side of the abdomen. The opening into this is a little above its commencement (Fig. 99). The part below is called the cœcum, and an appendage to this, the use of which is not known, is called the vermiform (worm-like) appendage. Collections are very apt to take place in the cœcum, and more especially in the appendage, and when the food has not been thoroughly masticated, serious harm is sometimes produced by bits of substances lodging there.

Fig. 99.

Fig. 99—*c*, Cœcum opened. *a*, Valve-like fold for closing the opening *b*, from the last part of the second stomach *f*. *o*, Opening into the vermiform appendage *v*. *d*, Ascending colon entire.

263. At the opening from the ileum, into the cœcum, a "fold" of the lining of the latter, is arranged so as to act like a valve, and prevent substances from passing backward beyond that point. Commencing from the cœcum, the colon passes up till beneath the lower and front thin edge of the liver, when it curves and passes across the body, in the situation where bilious colic is usually felt, viz., in front of the duodenum, below or in front of the most dependent portion of the stomach, and above the jejunum (Fig. 96). At the left side it turns abruptly downward, (Pl. 3, Fig. 1) is seen situated a little behind the small intestines. When it is traced as far as within the hip, it is observed to make two curves, called the sigmoid (S-like) flexure of the colon, by which it arrives in front of the sacrum. The remaining portion being straight, is called the rectum. The cœcum and rectum are quite closely confined in their places, but the remaining parts of the large intestine are allowed a great deal of motion, which is continually produced by one cause or another of pressure.

264. These parts are constructed much in the same manner as the second stomach, except that the longitudinal muscular fibres are gathered into three bands, the circular fibres, though found in the whole extent, are much more numerous at frequent points, causing the color to appear like a series of pouches; the inner surface resembles, though somewhat different, the lining of the second stomach; the lacteals are fewer in number, and denied by some to exist.

265. All the organs concerned in the second process of digestion require a free supply of good blood, nervous influence, and the indirect action of the mind. The performance of their office will then depend upon the perfection of the process in the first stomach. Nothing further need be now said in respect to food, except to show the importance of having a greater or less portion of waste substance combined with it.

266. Every organ suffers if it be not exercised in accordance with the intentions of nature.

She has given to man a stomach, differing in size in different persons. The muscular fibres of it can act with more energy when it is nearly full, as they can at best contract not more than half their length; and muscles are most effective when they begin to contract. At times only a small amount of food is needed, and that it should be combined with waste substance, producing bulk, is evident from the fact, that in summer, when little food is required, either to warm or repair the system, (for a person feels languid and cannot exercise as energetically as in cold weather,) nature furnishes vegetables and fruit, which contain but little food and much waste, and the warmer the weather, the more luxuriant is vegetation. By exercise, also, the muscular fibres of the stomach and second stomach become strong; and as the action of every part of the body is much influenced by habit, it is important to secure the regular action of these organs.

267. The comparative amount of waste substance to be used by different persons is different, and must be estimated by each individual upon principles set forth when the digestive canal is hereafter again noticed as an excreting organ.

In conclusion, of the digestive organs it may be laid down as a golden rule, that ALMOST EVERY THING IS GOOD FOR FOOD, IF ONLY EATEN IN ITS SEASON, AT A PROPER TIME, AND IN A PROPER MANNER, PROVIDED A PERSON WILL NOT EAT TOO MUCH OF IT. MOST PEOPLE EAT TOO MUCH.

CHAPTER II.

THE CIRCULATORY ORGANS.

General Observations.

268. These parts of the body have much to accomplish. That every part may be of a healthful temperature, there must be a very rapid passage of fluid through every part, that the heat produced in one part may be distributed to other portions of the system ; for as soon as the circulation languishes, the body begins to suffer from unnatural temperatures.

269. As some parts are at times exposed to lose heat much faster than other parts, there must be an arrangement for increasing the quantity of heat-giving fluid the parts naturally receive.

270. That every part may be properly nourished, it must constantly be visited by the nourishing fluid of the bloodvessels ; for of certain substances which the part requires, the blood contains but a very limited supply ; therefore at times a very large amount of blood will flow through a part before it has its needs satisfied ; and as each part requires much more nourishment at one time than at another, there must be an arrangement for increasing the quantity of blood the part shall receive.

271. That the waste substance constantly produced in the body may be as constantly removed, an active circulation of blood, increased as any particular part shall require, will be necessary.

272. That every part may be cooled as the case may require, it will be necessary that the circulation be active, and increased or diminished, generally or particularly, with the utmost accuracy.

273. To accomplish this purpose, two sets of fleshy tubes will be necessary, the divisions of which must be so minute that the life-giving blood may visit every part. One set will be required for the blood to pass *to* every part through, and another set for it to pass back through.

274. But as the tubes are exceedingly small in most of their branches, and liable to be bent and pressed upon, there must be some force which

shall drive the blood in its constant and rapid course—a force which shall be more or less active, as the case requires. For this, nothing will be better than a muscular bag or pouch; for by the contraction of its fibres, its contents could be forced to the extremities of the body with the desired rapidity.

275. The action of this muscular bag, called a heart, must be constant as ever during the night, and in the soundest sleep there is a great deal of action necessary in the body, and of course blood is required, as well as also to keep the body warm. The influence which controls the circulation cannot, therefore, be exercised by the mind, but is derived from the organic nervous system. There is, however, no part of the body which exhibits more clearly than the organs under consideration, the influence of the mind. The flush on the cheek, the quickened pulse, &c., produced by the emotions, will convince any one that the state of the mind is an important matter when treating upon the causes which compel the blood to quicken or delay its speed.

276. There are two ways by which the quantity of blood circulating to any part may be increased; it can be done either by increasing the power and rapidity of the heart's action, or by enlarging the capacity of the vessels of a part. If the first thing be done, the circulation of the blood in all parts is increased; if the last thing be done, the circulation in only the desired part is increased.

277. Sometimes one of these ways, sometimes the other, sometimes both are necessary. An additional cause may sometimes be in action, viz., at the same time the bloodvessels of one part are enlarged, those of some other part or parts may be lessened.

278. But as the whole apparatus of the circulatory organs has reference to the blood, viz., to keeping it moving through the various parts of the body, and in the quantity the parts require, it will be proper in the first place to consider the blood.

The Blood.

279. Blood is obtained from three sources, strictly speaking. The food, the drink, and the air we breathe; but it will be proper, also, to say that the blood is obtained from the decomposition, or wearing out of the body, which is constantly taking place.

280. The quantity of blood is constantly varying according to the quantity of substance added to it from the food, the drink, the wearing

out of the body, and from the air, or taken from it to nourish the body, to cool the body, or by the excreting organs.

281. The thickness of the blood varies very much; sometimes it is very thin and watery, at another it contains much solid substance in a state of solution. If a person quench his thirst by a large draught of water, the blood is thinner by so much; if he perspire freely and do not drink, his blood becomes thicker.

282. The color of the blood varies. In the body ordinarily, the blood is considered to be of two colors, a crimson red, viz., blood color, and a dark red or deep purple, sometimes called black. It is red in those vessels through which it goes out, and purple in those through which it comes back. But the brightness of the red and the depth of the purple depend upon a variety of causes. The change of color from red to purple takes place in every part of the body, and of course, must be produced by some cause which is operating in every part; and as this change takes place in parts which seem almost, if not entirely at rest, the cause would seem to be some one which had reference to the production of heat, especially as it will be found that,

283. The blood changes from purple to red in the lungs, and upon the perfection with which this takes place, will depend the heat of the body. The change of color may be, and doubtless is, an accidental thing; but as the proper color is always indicative of proper blood, it is very common to designate the qualities of the blood by its color.

284. The change in the color of the blood from red to purple will depend upon the quality of the blood, and the activity of any part through which it passes. The more active any part is, the deeper purple will the blood assume on its return. The more active the body is the warmer is it; the more heat is there produced. This would seem to show that those same changes which produce a change in color, produce heat also.

285. The change in the color of the blood from purple to red, depends upon the quality of the blood, and the quantity and quality of the air acting on the blood in the lungs.

286. The quality of the blood is constantly varying. From the food, it receives ingredients to nourish, and fuel to heat the system, and from what is eaten, many things pass into the bloodvessels and become a part of the blood, which are not for its good. Its nourishment is continually taken from it by the demands of the parts through which it is passing, and its fuel must be constantly used to produce heat. The wear of the body, or its decomposition, is constantly adding to it substance, which

it is the duty of the excreting organs to remove. This, they sometimes do promptly, sometimes tardily, so that sometimes the blood never contains more waste substance than is for the health of the system, and sometimes it is diseased by the slackness of the excreting apparatus. The quality of the blood usually varies as its color.

287. The composition of the blood varies as does its color and quality; in a general view it is very similar to the chyle, containing the various constituents which enter into the form of the body, and many which have served their purpose in that respect. It will not be worth while to examine it minutely. If it be allowed to remain quiet a few moments after it is drawn, it will separate into a dirty yellow fluid, and a red clot which sinks in it, the fluid is called serum, and sometimes, the white blood. If the clot be thoroughly washed with water, it will become white, and it will be found that its red color was given to it by blood-globules, as they are called, that is, substances of a rounded form, like balls somewhat flattened. They are larger than many of the small vessels, and cannot, if they be healthy, pass into them. What particular office they fulfil is not known. If their duty had been one half what has been assigned to them by the conjecture of one person or another, there would have been but little use for any thing else in the body.

288. It is a question of great moment, and has never been settled, whether the blood contains the ingredients that every part requires, and which therefore, has only to separate from the rest of the blood, that which it wants, ready formed for its use, or contains only the elements in a certain compound state, which each part is to take from the blood, and combine in that way which adapts them to its need. It is also a question of a similar kind, whether the substances to be removed from the blood, exist in it in the same combination as when removed, and are therefore only removed by the excreting organ, or in such a combination that the excreting organ is obliged to form a new substance, taking from the blood only a part of several different compounds.

289. Before considering the apparatus of circulation, it will be important to take notice of a fact developed in the course of the last few paragraphs, viz., that the blood in passing through any organ, whether active or to all appearance inactive, is changed in color and qualities to a certain degree; to be restored from which condition it is necessary the blood should be exposed to the air—for which purpose the lungs are provided.

290. Another two sets of vessels will be required, viz., one set through which the blood shall be carried into the lungs, to be acted on by the

air, and another set to bring the blood back after it has been acted upon; and a forcing apparatus or heart, will also be required to drive the blood through the lungs.

291. The importance of this last arrangement is very evident, when from any cause the lungs fail to perform their duty, and it is all the same as if the blood did not go through them; the vigor of the system is impaired, its warmth is lessened, the mind is oppressed, the skin becomes sallow or livid-like, digestion fails, and every part of the system bears witness to the need of the action of air upon the blood.

292. The blood which returns from the lungs, is also warmer than it was when it entered them, which is undeniable proof of the utility of the lung-circulation, as it is sometimes called.

293. There are, therefore, said to be two circulations—the greater and the lesser; but in fact there is but one circulation, viz., as represented in Lith. Pl. 4, Fig. 2, the blood is thrown out into the body, from which so much as is not used, with the waste of the system returns; not to the same heart from which it went out, but the heart which throws it into the lungs, from which organs it passes to the heart from which it was considered to start, and from which it is again poured out. It thus passes a continual round until it is somewhere used, when it occupies a stationary position for a longer or shorter time, and then comes back, having served its purpose, into the bloodvessels; and again passes the rounds perhaps once, perhaps a thousand, perhaps a million of times, till it is cast out of the system. The power which produces this motion of the blood, may next attract attention.

SECTION 1.—*The Heart.*

294. What is usually so called, is in fact composed of two hearts, viz., the heart that drives the blood through the body, and the heart that throws the blood into the lungs (Fig. 100).

Like two houses under one roof, they are placed together for the purpose of saving substance in their structure; but they have no farther connection with each other (Fig. 101). In some animals the hearts are separated for a short distance, as in the dugong.

295. The hearts are muscular bags or sacs, with very thick, strong sides; the fibres interlacing in every possible

Fig. 100.

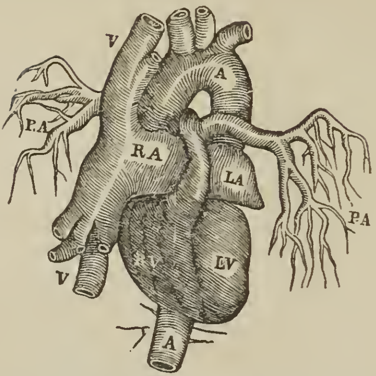


Fig. 100.—The two hearts in contact. R, A, Right auricle. R, V, Right ventricle. L, A, Left auricle. L, V, Left ventricle. A, A, Aorta. V, V, Veins. P, A,—P, A, Pulmonary arteries.

direction, leaving but a small cavity of from one to three ounces capacity within.

The left or back heart is much the thicker and stronger, as it should be, its duty being to throw the blood to the extremities of the body; while the right or front heart has only to force the blood through the neighboring lungs.

296. Each heart is composed of two parts (Fig. 101). The upper part is called the auricle; it is much thinner and weaker than the lower part, which is called the ventricle.

The duty of the upper part is merely to force the blood down into the ventricle; and some suppose it is not usually active in performing this duty, but that the blood rushes into the ventricle as it opens.

297. Between the auricle and ventricle of the right heart, there are found valves as they are called—their particular names being the tricuspid (three-pointed) valves. They are tendinous substances, attached round the opening between the auricle and ventricle (Fig. 102). They are quite smooth, and entire near the opening; but a little distance from it they are

Fig. 101.

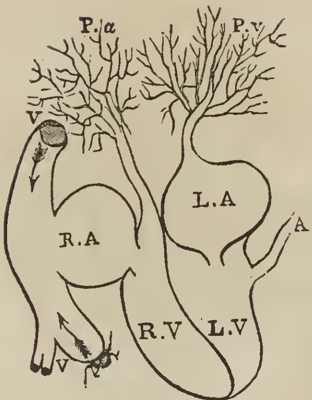


Fig. 101.—Ideal representation to show the facts of the circulation of the heart. Through V, V, the blood passes into R, A, from which it passes into R, V, and goes out through P, *a*. Coming back through P, V, into L, A, it passes on into L, V, from which it goes out through A.

composed of a great number of cords, which are connected with short, fleshy columns on the inside of the ventricle, opposite to the opening. These fleshy columns are muscular, and by proper relaxation allow the valves to close the opening, or draw them into the ventricle, as the case may require.

298. By the situation of these valves it is seen that the blood will be allowed to pass through the opening in one direction only, viz., from the auricle into the ventricle. A similar arrangement exists in the left heart, except that there are two valves, called mitral (from their form resembling a bishop's mitre).

299. At the opening leading out of the ventricle (Fig. 103) there are three half-moon shaped valves, without tendons or fleshy columns to move them, but depending entirely upon the pressure of the blood.

When by contraction of the heart, blood is forced against the inside of the tricuspid and mitral valves, and causes them to close the opening into the heart, the semi-lunar (half-moon) valves are raised by the pres-

Fig. 102.

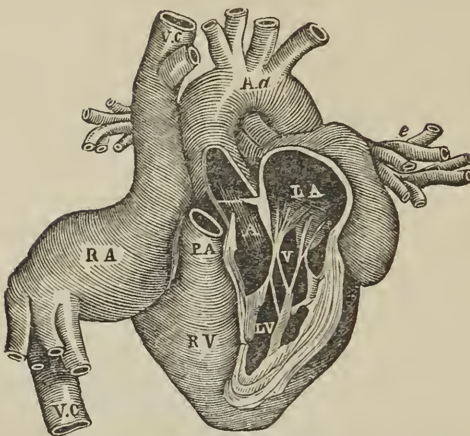


Fig. 102.—The letters exhibit the same parts as before, except that V, represents the mitral valves. No piece of the heart is removed, the heart being merely cut open.

Fig. 103.

Fig. 103.—The dart shows the direction of the current. By the sides of the dart representations of the open semi-lunar valves are seen. When closed, the edges overlap each other, while between the edge and the side of the vessel the valve "bags" down.

sure upon their inner or under surface, and the blood passes through between them; but *vice versa*, when the contracted heart begins to relax or enlarge and open the tricuspid and mitral valves, the semi-lunar valves are immediately closed by the pressure upon their upper surface of the blood attempting to pass back.

Frequency of Pulsations.

300. The number of contractions of the heart per minute can be counted either by feeling the pulse, or by placing the ear upon the chest and listening to the pulsations, as they are called, of the heart. They will vary in different persons, in the same person at different periods of life, and in different states of health, and according to the exercise.

301. In some persons in the prime of life, the pulse beats but 50 times per minute, in others it is regular, and 100 per minute. In the female it is quicker than in the male, all other things being equal. In infancy it is 120, 110, 100; in old age, 30, 50, 60; in prime of life it averages 75 for men, 80 among women.

If we say, however, 64 for ease of computation, the result will be astonishing, counting also that the heart throws out but one ounce of blood each "beat." This will give 64 ounces, or four pounds per minute, 240 lbs. per hour, or 5760 lbs. in the course of a day and night, and the same amount which one heart throws into the lungs the other heart throws into the body. But the labor of one heart at half its true amount, is moving nearly three tons of blood per day, or if the amount be computed in quantity, 240 pounds may be considered as 240 pints; 120 qts.; 30 galls., or a barrel of blood in the course of an hour.

302. The importance of the heart is altogether beyond ordinary thought. Its labors are truly amazing, and the mind is almost lost in wonder when it considers how small the heart is, hardly larger than a man's fist, beating on from infancy till death, without, in any case, an irregular pulsation, now quick, now slow, but always right; and yet how delicate it is made in some of its parts! Why does it not, like the works of man, fail at some point?

303. The heart occupies a position in the chest, as in Fig. 97. Its point or apex is situated in the left side, within the space between the cartilages of the sixth and seventh true ribs, at the point against which the heart is felt beating, and which is usually thought to be about the centre of the heart, but is its extreme left and lower point. The base or

roots of the heart are near to the back-bone, and back of the breast-bone. It, therefore, is placed in an oblique manner in the chest. It partially rests below upon the central part of the diaphragm, and is partly supported by tendinous roots, which connect it with the back-bone, and partly by suction of the chest.

304. The heart is surrounded by the "heart-case" or pericardium, a strong fibrous pouch, used frequently as a money-purse. It is not connected with the heart except at the roots. It is lined by a serous membrane, which also covers the heart. Its free surface is moistened by a small but sufficient quantity of serous fluid. It sometimes increases very much, producing dropsy of the heart.

305. Upon each side of the heart, connected with the back-bone, the breast-bone, and the diaphragm, thus dividing the chest into three apartments, is found what is called the mediastinum, as if the two made but one.

Section 2.—*The Bloodvessels.*

A. *The Arteries.*

306. The arteries are the bloodvessels which lead out from the heart (Lith. Pl. 4, Fig. 1).

They must be so formed that they will allow or assist the blood to pass easily through them to every part of the body.

307. They are, therefore, formed of three coats, the outer one being dense, firm, and protective, in such manner that when the artery is cut across it will remain open to a considerable degree, much like a quill, though the sides of the artery are not so unyielding as the sides of a quill.

This is as it should be, for the bloodvessels are constantly subject to pressure by one cause and another. The outer coat is, however, yielding to a certain degree.

308. The middle coat is composed of yellow elastic fibres, which some think actively contractile.

By means of this, the diameter of the arteries is considerably lessened when they are cut across.

309. The inner coat of the arteries is a very smooth, delicate membrane, a continuation of that which lines the heart.

310. In the next place, the arteries branch from each other, at acute angles (Fig. 104).

Fig. 104.

Except in case of a few large ones near the heart, which are so arranged, that the blood flows into them in the easiest manner.

311. In the last place, the branches of the arteries open into each other, in many places.

By this means, the blood can be supplied to various parts, by various channels (Lith. Pl. 4, Fig. 1); as when a street is obstructed, a person can drive through a side street, and come back beyond the obstruction, so it is with the blood, which sometimes goes a long way round, but with such rapidity, that no inconvenience is suffered.

312. The arteries are almost infinite in number, and found in every part of the body, larger and more numerous in some parts than others, which is because some parts require more blood than others. They are called by two different general names, according to their destination, and by different particular names, according to their situation.

313. The pulmonary, or lung arteries, is the name given to those which are destined to lead the blood into the lungs.

The blood which they contain is not for the purpose of nourishing the lungs, but is to be acted upon by the air drawn into the lungs, and thus fitted to serve the wants of the body.

314. The lung arteries commence by a single artery at the top of the ventricle of the right heart, half-moon or semi-

lunar valves being found at its commencing point. By their action, the blood once received by the artery can never go back, but its course must be "onward." The artery is very short, before it divides into two grand branches (Lith. Pl. 3, Fig. 2), one leading to the right, the other to the left lung, which is entered by the side of the windpipe, at every division of which, the pulmonary artery divides, and thus visits every portion of the lungs, and reaches every air-cell.

315. The systemic or system arteries, is the name of those which lead the blood into every part of the body.

Branches of them supply the heart, which derives no more benefit from the blood it contains than any other part of the body, the blood not nourishing it till thrown into the arteries, in some small branches of which, the blood meanders through the heart, and nourishes it. No more do the arteries derive any selfish benefit from the labor they perform, in respect to the blood; they are not allowed to "toll it," but are nourished by a set of small vessels, in the same manner as other parts of the body. Some branches of these arteries are distributed through the lungs, which have derived no peculiar benefit from the visitation of the blood from the right heart.

316. The systemic arteries commence at the top of the left ventricle, by a single large vessel, the grand aorta, which rises up nearly to the top of the breast-bone, where it forms an arch, at the summit of which it allows branches to pass to the right arm and the right side of the head, without and within, and to the left arm and left side of the head. *The branches passing to the head are very large, and allow more blood to pass in proportion to the size of the head*, than exists in any other part of the body, except the kidneys. This indicates the importance of the changes which take place in the head, or which should take place in the head. The aorta then follows down on the left of the middle of the back-bone, giving off branches to the ribs, large branches to the digestive organs, especially the second stomach, and to the kidneys.

The importance of the action of these organs is therefore great.

317. Before it reaches the pelvis, the aorta divides into two grand branches, which extend into the lower extremities. The situation of the main artery of the leg, it is best to notice, as whatever stops the flow of blood in that, checks the flow of blood from any injured lower division. Coming out from the abdomen, the artery called femoral in this place, immediately finds its way to the midst of the leg, upon the inside of the thigh-bone. Where it comes out from the abdomen over the hip-bone, is a very good place to exert pressure upon it, as the bone is directly below, and allows a person to exert pressure with effect. Its direction is not straight, as its object is to get behind the knee; its course may be known, however, by the tailor's muscle (Lith. Pl. 1, Fig. 1), as it is directly below the inner edge of that muscle (Fig. 105).

318. The firmness of the artery, and the large amount of fleshy substance beneath and upon which it is imbedded, renders it very difficult to compress the artery. It can however be accomplished, by tying a knot in a handkerchief or any strong band, and by putting the knot over the edge of the tailor's muscle, the ends of the band being brought to the opposite side of the limb and tied together snugly, but with a little length of bandage between the last knot and limb, that a stick, iron, or any handy thing may be put under and twisted round, thus forcing the first knot to compress the bloodvessels. To do this better, something—a few pennies, a smooth stone, or bit of wood—may be placed under the first knot, which will then press all the more forcibly. If the knot do not happen to be over the artery, it can be moved a little to one side or the other; but every thing must be done quickly.

319. The situation of the artery of the arm may also be noticed (Fig. 106).

Where it comes over the first rib it may be pressed upon with the advantage of the bone beneath, but the most convenient place at any time is found in the arm, in which the main artery lies deeply buried. The inner edge of the biceps muscle, so easily felt on the front part of the arm, is over the artery, and therefore a guide to its situation. It may be acted on in the same manner as the artery of the legs. If the bloodvessels of the head bleed badly, it is easy to make pressure upon them.

Fig. 105.

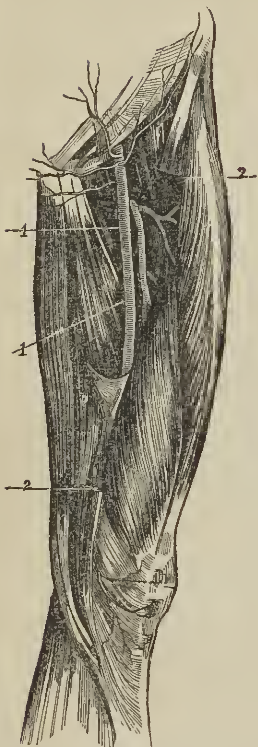


Fig. 106.

Fig. 105.—2, 2, Divided ends of "tailor's muscle." 1, 1, Femoral artery.
Fig. 106.—Arm, with parts removed to show the situation of the main artery.

320. The arteries which enter the head pass through a canal winding in the bone, as if there were danger to be apprehended from allowing the blood to rush with great force to that grand nervous centre contained in the skull.

321. There is one thing exceedingly interesting, and very important, in respect to the arteries. They are

buried deeply below the surface in almost all parts of the body.

The object of this is, in the first place, *to protect them from danger.* This is so important, that sometimes the arteries are seen partly or wholly surrounded by a long bony channel, as observable in the under edges of the ribs.

322. But another still more important and also constant benefit arises from this, that the blood in the arteries is kept warmer.

When it is considered that one very important duty fulfilled by the blood is to convey heat to parts where it is needed, the value of this arrangement of the arteries will be appreciated. To understand this fully, however, a few general remarks must be made.

323. A great portion, if not all the heat of the body is produced in the central organs; chiefly or wholly in the lungs, for the blood is not so warm when it enters as when it leaves them. It is found by experiment that the temperature of the stomach averages about 100 degrees, the heart is a little warmer. The throat has an average temperature of 98, the top of the brain 96, the hands 94, the feet 92. *Now one of the most important duties to be fulfilled in the protection of health, is to keep the various parts at their natural healthful temperatures.* The instant any part rises or falls in temperature, a person begins to lose health.

324. It is also evident that any part will be kept warm, all other things being equal, in ratio with the quantity of blood it receives and its distance from the heart.

The head, therefore, will be always warm enough, as the blood has but a short distance to go, and flows to the head in very large quantities. There is, therefore, a reason for the old proverb, "keep the head cool." There is also a reason why the head should perspire sooner than any other part of the body, viz., it will need cooling earliest. There is a reason why the head should not be covered with fur caps, &c., as they keep the head too hot, except in the coldest weather. There is a reason why infants should not have caps upon their heads. There is, also, a reason why the face does not need a covering except in the coldest weather, viz., it is supplied with a large quantity of blood directly from the heart. There is, also, a reason why neckcloths, &c., tend to produce

sore throat, inflammation there, &c., and why the custom of ladies to leave the upper part of the neck uncovered is more advantageous than the fashion of men.

325. We find in respect to the throat and head, that nature has not buried the vessels deeply until it was necessary for reaching the parts within the skull; for the arteries leading to the head are situated near the windpipe, through which the air is constantly passing, and of course cooling the blood in its vicinity.

326. The distance to the hands and feet is great, and the quantity of blood flowing to them comparatively small.

The arteries* are, therefore, buried deeply, that the blood flowing through them, may not be too cool before it reaches its destination. For accomplishing this purpose better, a deposit of fat is made in cold weather; to which ingenuity and judgment should add clothing, as need may be.

327. It cannot, therefore, be said with any propriety, that a child by "habit," is "just as well with short sleeves" as long ones.

It will not be denied by any, that habit would do something toward lessening the evil which results from clothing too thinly—it can, however, do but little. If the hands, arms, and feet be kept perfectly warm, that is sufficient; but if they be not, either the quantity of blood moving through the part in a given time must be increased, or such coverings worn as shall prevent the blood which visits the part, from becoming cold before it arrives there.

328. Two facts are worthy of notice, before leaving the arteries. In the first place, they are merely channels of communication from the heart to all parts of the body.

The blood is the same in all respects, except its temperature, when it leaves the arteries as when it left the heart.

329. In the second place, the blood differs in temperature, color, and quality in the different sets of arteries.

It is not, therefore, the character of its contents which renders it necessary a bloodvessel should be an artery. But if the blood be driven

* It was, therefore, the expression of an *ignorant* Indian, who said—as we are told—that he was "all face."

by the heart directly into a vessel, it must be constructed like an artery, to wit, it must be an artery.

B. *Capillary Bloodvessels.*

330. The capillary (hair-like) vessels are so called from being very small.

How their walls or sides are formed, or what particular properties they possess, is not certainly known further than this—they are capable of enlargement and diminution, to how great a degree compared with their ordinary size, is not known.

331. They exist in the form of a network (Lith. Pl. 3, Fig. 3), where it is seen very much magnified. This network of capillaries exists in every part of the body.

It is much more extensive in some parts than in others—that is to say, the vessels and the meshes of the network are naturally larger in some parts than in others.

332. The blood flows from the arteries into the capillaries, and in them undergoes *all* its changes, except in temperature.

That is, in them its color is changed; through them the parts of the body are nourished, &c. How this is accomplished, is not known. Some suppose that the part of the body requiring any thing existing in the blood passing through the capillaries, has the power of drawing or attracting it through the sides of the capillaries. Some suppose that the capillary has an active agency in all such operations. How *far* also from the capillary any part may be influenced by the blood of the capillary, or exert an influence upon it, is conjectural. The distance from one capillary to another is not great, but yet it is something, and substance exists there; undergoing frequent changes, and it must, therefore, pass a short distance before it can pass into the capillary, or from the capillary to its needed place.* Hence different parts will be nourished with different degrees of rapidity; and it might be expected, as is the case, that one part would be very quick and another very slow in recovering—espe-

* Some suppose, that substance is constantly leaving the capillaries, and traversing more or less slowly the spaces between them, if it do not happen to be needed on the way.

cially considering one thing besides, viz., that some parts, when injured, would require for their restoration a large amount of substance, which is usually found in the bloodvessels in very small quantity.

333. Thus, when the bones are broken or the tendons injured, especially after the body is mature, they will be very slow in recovering; for as they do not, day by day, require to undergo very rapid changes, the bloodvessels in them are not very numerous, comparatively speaking; they also require substance comparatively rare in the blood. Whoever, therefore, has a broken bone, must expect it will be useless a long time.

334. Also when the ligaments are sprained, the part must be kept quiet for a long time, that the healing process may take place. For though the reason of it cannot be given, it is a fact that substance newly formed, is not as perfectly adapted to its purpose as after it has undergone its changes many times: hence the muscles of the rapidly-growing child are apt to allow the back to lean; a bone newly united is easily broken again; bones dislocated and replaced, are thrown out of place more easily a second time, if it occur within a short period. The substance which forms a scar, is more easily affected by disease than proper flesh; and the more recently it has been formed, the more easily is it diseased. A slight exertion may, therefore, undo all that nature has done in effecting a cure.

335. It is also worthy of notice, that if the capillary vessels become distended with blood, they cannot perform their duties in nourishing or otherwise acting upon any part.

This state of the vessels is called congestion, when the blood is stagnant, if such an expression may be used, or when the blood moves very slowly; but when the vessels are unnaturally full of blood, moving actively, a state of inflammation exists.

336. When any part is to be restored from injury, therefore, two things are to be kept in mind. The blood must not be allowed to circulate too freely; and on the other hand, its circulation must be as active as is allowable.

C. *The Veins.*

337. The veins commence in the capillaries of every part of the body, and lead the blood back to the right heart, with the exception of the veins from the pancreas, stomach,

second stomach, and spleen (Lith. Pl. 4, Fig. 4), which unite and form the portal vein leading into the liver, and one class of veins which (Lith. Pl. 3, Fig. 2) lead the blood from the capillaries about the air cells of the lungs to the left heart, (Lith. Pl. 4, Fig. 2).*

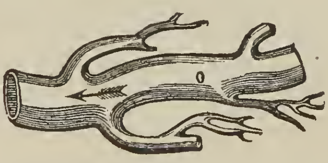
It may be here observed, that opening from the capillaries of the liver and lungs there are veins which lead to the right heart.

338. The veins have three coats. The outer one is similar to the outer coat of arteries, but is not as firm. The middle coat is very thin, and said by some not to exist. The inner coat is like that of the arteries, and is a continuation of the lining of the heart.

When the veins are cut across they do not remain open, like an artery, but are closed with slight pressure. When they have been cut, a bandage upon the wound is quite sufficient, especially if assisted by the application of cold.

339. As the veins unite with each other, they form very obtuse angles as a general thing, as seen on the back of the hand and in Fig. 107, while in case of the arteries they are joined at very acute angles. Within the veins are found "folds" of the inner coat (Fig. 108), which answer the purpose of valves to prevent the blood from flowing back.

Fig. 107.



The position of these in the veins of the back of the hand will be noticed if the fingers be drawn down on its back, a little in front of the

* The veins of the portal system will be considered in connection with the excreting organs, and the veins leading from the lungs to the right heart will be considered when treating on the lungs.

Fig. 108.

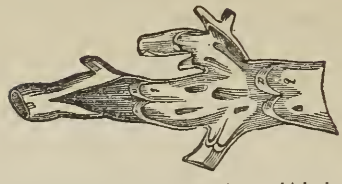


Fig. 108.—Vein cut open to show valves, *a*, *a*, above which the pouching parts, *b*, *b*, are seen.

fingers small "lumps" will be seen. These are where the valves resisting the blood cause it to distend the veins. A little above the finger, from certain points, some of the veins will appear empty. These points are, also, the places of valves which prevent the blood from flowing into the empty veins.

340. *These valves do not exist in the head.*

As it was the intention of nature that the head of man should be upright, hence the head should not be held "down" long at a time, as the blood runs back into the head. Children should not turn "somersets," "stand on the head," nor should any one sleep with the head level with the body, especially if he be subject to any nervous affections. A child should not be placed on the lap or carried with the head down. The bed for the child should be made upon scientific principles, with the head the highest, the trunk the lowest, and the feet intermediate.*

341. The veins anastomose or open into each other, very frequently, and are of two kinds. The large veins situated directly beneath the skin, being called the superficial veins. The others being called deep veins, and are for the most part found in company with the arteries, each one of the main arteries being accompanied by two veins. Thus the veins are much more numerous and capacious than the arteries of the body.

* There is as much art in making a bed well, as in making good bread. The bed should be level from side to side, as otherwise there is much fatigue produced by retaining the position of the body during sleep, and a person feels in the morning as if he had been rolling down hill all night. If the foot of the bed be a little too low, the blood has difficulty in finding its way back to the heart, &c., &c.

342. All the veins from the upper parts of the body, at last unite, and form one (Lith. Pl. 4, Fig. 1), called the descending vena cava. All those from the lower parts of the body, unite to form one (Lith. Pl. 4, Fig. 1), called the ascending vena cava. The venæ cavæ terminate or open into the right auricle.

D. *The Lymphatics.*

343. Lymphatics is the name given to a class of vessels which exist in many parts of the body. The name is given on account of the pellucid fluid called lymph, which is found in them.

344. The largest of them are very small, and they all have much the appearance of a string of small beads (Fig. 109), which is produced by their valves, something like those of the veins, which are very numerous, and formed of folds of the inner coat of the lymphatic, which "pouches" between the valves.

Fig. 109.

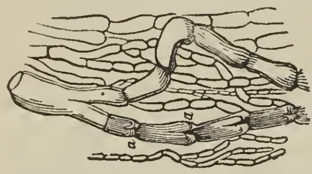


Fig. 109.—Lymphatic vessels, one being cut open to show the valves *a*, *a*.

345. How the lymphatics commence, is not well determined. When first plainly seen, they appear in the form of a network, which some believe to communicate with the capillaries, but which others think commence independently of any other vessels.

346. The proper lymphatic vessels commence from this network. They are composed of two coats, the inner one of which is formed into folds, as said. Their course is nearly parallel, and throughout the whole of it, they increase but little in size. Their course is nearly in a direct line from their commencement to their destination, viz , the bloodvessels at the root of the neck.

347. They communicate with each other, but not as frequently as the veins or arteries, and by branches no smaller than the main trunks, from which they pass, or which they form.

348. In their course are situated softish bodies, called glands, half or two-thirds the size of a kernel of corn. Some are larger, others smaller. They are very fully supplied with blood vessels. The vessels which enter these glands are more numerous and a trifle smaller than those which leave them (Fig. 98).

349. The lymphatics and their glands are of three kinds. The *superficial* are found immediately below the surface of the skin. The *deep* are found following the course of the deep veins. The *lacteals*, heretofore described, are considered as a third class of lymphatics, as their structure is similar, though the office of the lacteals is well known, but that of the lymphatics not.

350. Some suppose that many of the small lymphatics terminate in the roots of the veins, and that branches of the lymphatics open into the larger veins; but this probably is not correct. The lymphatics from the lower part of the body find their way to the thoracic duct, which opens into the veins of the neck, on the left side; at the same point also, terminate the lymphatics from the left side of the head, left arm, and left side of the chest; while the lymphatics of the right side of the head, right arm, and right side of the chest, terminate at a point of the neck-veins on the right side, corresponding to the termination of the thoracic duct.

351. The fluid found in the lymphatics is very similar to the serum of the blood in general appearance. They are sometimes filled with it, and sometimes nearly empty.

352. The arrangement of the valves signifies which way the lymph moves. The force which moves it is thought by some to exist in the lymphatics themselves, by others to be derived in part from the capillary bloodvessels, and, perhaps, even the heart acting through them. Others think the manner in which the lymphatics open into the veins draws the lymph on into the bloodvessels; but the only, as yet, certain force is found in the pressure of the contracting muscles, and rubbing the system. How much importance is to be attributed to the circulation of the lymph, is not known; but it is worth while to notice the advantage of exercise and rubbing, in increasing the rapidity of the motions of the lymph.

353. The utility of the lymphatics is not known. Some suppose they absorb all the waste substance that is produced by the wear of the system. But as no lymphatics have been found in the nervous substance, in the bones, cartilages, muscles, or tendons, this view is, without doubt, in-

correct. Others think that the lymphatics are merely for the purpose of taking up fluid substance which is not of use in any part of the body; but the above objection would apply to this view. Others again think that the lymphatics take up all substance which passes into the body from without, either through the stomach, the lungs, or the skin; but there are objections to this view. Our minds must therefore remain in that unsatisfactory state, which is very disagreeable, but yet most profitable, if sufficient facts are not known to establish any point.

354. When colds are taken, the lymphatic glands are very apt to be affected—to swell and become hard, forming "kernels" in the neck and elsewhere; this is the case more particularly with persons of a "consumptive constitution." Why it should be so, cannot be told. When certain parts are injured or diseased in peculiar ways, inflammation is very apt to extend in the course of a lymphatic vessel, perhaps affecting but one of them, but extending in it very rapidly. The particular reason for this cannot be given.

Section 3.—*Causes of the Circulation.*

355. The contractions of the heart are the most powerful causes which distribute the blood through the body.

As these are affected by the emotions and various states of the disposition, and as otherwise it beats with increased or diminished rapidity, as the wants of the system require, it follows that

356. The action of the mind and organic nervous system, and of course the state of the general health, have a powerful influence upon the circulation.

Hence the physician feels the pulse, to learn the condition of his patient.

357. The arteries dilating, receive the blood from the contracting heart, and reacting upon the blood when the heart dilates or relaxes, they force the blood backward against the semi-lunar valves—closing them, by which the whole pressure of the arteries urges the blood to their extremities.

Some suppose the arteries contract and relax alternately with the

Fig. 109 (B).

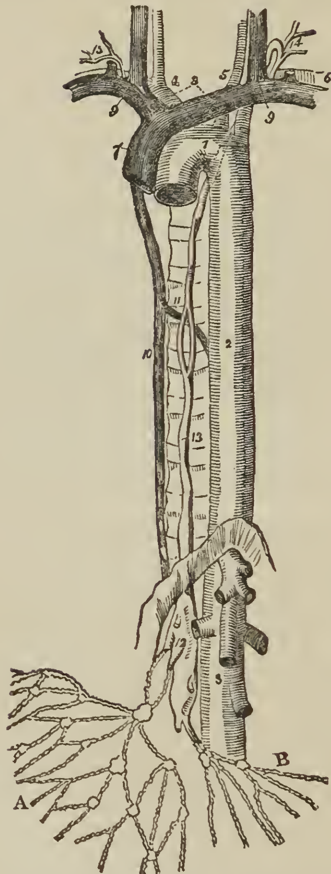


Fig. 109 (B).—1, 2, 3, Aorta. 4, 5, 6, Arteries, branching from the aorta. 7, 8, 9, Veins. 10, 11, Certain veins, called venæ azygos. 12, Enlargement of the thoracic duct, called the receptaculum chyli. 13, 14, Thoracic duct. At 14, a lymphatic vessel is seen opening into the thoracic duct. 15, Lymphatic of the right side. A, Lacteals commencing from the second stomach. B, A portion of lymphatics from the lower parts of the body.

heart. Others suppose that the action of the arteries is wholly dependent upon what is called the elasticity of the arteries. In either case

358. What may be called the life of the arteries will depend upon the state of the nerves, and

Consequently, the circulation through the arteries is influenced by the general health. Some also think the arteries can be increased or diminished in size, as need may be, under the action of the nervous influence. This may be the case with the minute arteries, but probably not with the large ones. Disease will however cause enlargement of both large and small.

359. Every eause of pressure will eause the blood to flow on, toward the extremities of the arteries.

Hence exercise of the muscles and rubbing the system increases the rapidity of the circulation.

360. It is however essential that pressure be made at *intervals*, that the blood may flow into the vessel from whieh it has been pressed.

Hence tight clothing is very injurious, by exerting *constant* pressure.

361. The arteries braneh at aeute angles (Fig. 106 and Lith. Pl. 4, Fig. 1);

Except those arising from the arch of the aorta, in which the course of the blood is such that it leaves the aorta more easily with the present arrangement.

362. The area of two branches is greater than that of the dividing artery, on aeeount of whieh the blood flows out more readily, as explained by Fig. 110.

363. The blood is also drawn onward through the arteries by the passage of the blood through the veins.

364. Cold tends to eontract the arteries.

If it be applied transiently, however, the nervous system will exert a counteracting influence.

365. The effieieney of the nervous system in this respect will depend upon the health of the person, and upon the extent of the action of the eold.

Fig. 110.

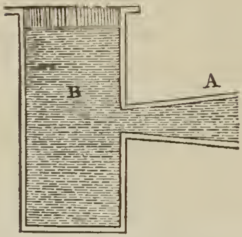


Fig. 110.—B, represents a fountain, the water of which, by its pressure, rushes out with greater force, on account of the increasing size of A.

If a person be exceedingly feeble, the cold will conquer from the first, if it act but upon a slight extent of surface ; and from this to a perfectly strong and healthy constitution successfully opposing cold for hours, there will be all grades of nervous power.

366. *Cold, transiently applied, is therefore excellent to arouse and increase the circulation of any part, if the health be sufficient.*

367. *Cold, continuously applied, will always overcome the nervous energies in time.*

Hence cold is excellent to apply when the vessels of any part are injured and bleeding, and when also it is desirable to check the too active circulation of blood. It must be applied *continuously.*

368. Heat and warmth, on the other hand, increase and relax the size of the bloodvessels.

Heat is, therefore, excellent to increase the flow of blood to any part, as may be seen by wiping a wound at any time with warm applications.

369. Heat applied for a great length of time, enfeebles the energies of the bloodvessels.

370. Many medicines and applications, as also many diseases, either enlarge or diminish the size of the arteries either directly or indirectly, through the nervous system.

371. It is self-evident, yet worthy of remark, that if blood be in one part it cannot be in another part at the same

time; and also that there is a given amount of blood in the system at any one time.

If, therefore, blood circulate too actively in any part, it may be diminished by applications to the part which will lessen the circulation there; or applications can be made to some other part to increase the circulation there, which must have a tendency to diminish the circulation in the first part—or both things may be done at the same time. Also the quantity of blood may be lessened by blood-letting.

372. Thus, physicians sometimes apply cold to diminish the circulation—as when a person has been intoxicated, it is usual to pump cold water on the head.

373. In case of apoplexy and various fits, physicians will rub the body every where, and make hot applications to the feet and hands.

374. In case of croup, warm applications are made to the feet; and cold cloths or the like, to the throat.

375. In case of inflammation of the lungs and many other parts, physicians are in the habit of applying blisters, mustard poultices, &c., or blood-letting, either with the lancet, or by leeches. It must be remembered, however, that other purposes are frequently served by blood-letting.

376. As a general rule, if the system be not very feeble, it is advisable to make use of both classes of applications at the same time, viz., applications which shall diminish the circulation of the affected part, and other applications to other parts which will increase the circulation there.

And as the bloodvessels are smaller the nearer we approach towards the surface, and as there are many causes which retard the circulation of the blood before it has reached the extremities of the arteries, and also because the surface of the body is continually exposed to the cold, on account of which the bloodvessels are liable to be contracted, if but a little,

377. It is exceedingly important that when there is any derangement of the circulatory system, the skin be rubbed very briskly, kept warm, &c., as the great difficulty will be found in keeping the circulation active near the surface, and preventing the accumulation of blood in the internal organs.

And as the action of the circulatory system is so much dependent on the nervous system,

378. When a person is sick, care should be taken to keep the circulation active in the skin by daily rubbing, brushing, &c.

It will also be evident that,

379. The circulation will be easily deranged when the system is exhausted.

Hence why people take cold more easily in the evening when exhausted by the day's labor, than in the morning when refreshed by sleep. Indeed, cold will many times be taken from exhaustion alone, or inflammation may be produced, as the system becomes too feeble to preserve an equal circulation in every part of the body. At least, when the system is exhausted, cold will produce a worse effect than otherwise; but if the system be warm, exposure to cold will not produce so speedy an effect as if the system be exhausted and also cold. A person never takes cold, therefore, because he is warm, but because exhausted. Usually, however, the causes which have produced the heat have exhausted the system; and as the warmth of the body is most conspicuous, the evil suffered is attributed to the system being too warm. A person, if warm and not exhausted, or if exhausted, will not be as likely, therefore, to take cold as if he were not warm. It not being the transition from hot to cold or cold to hot, which produces a bad effect, but the incapability of the system to counteract the evil. Taking a vapor bath, if not to the point of exhaustion, is not harmful, nor can a person take cold as easily after. To take a cold bath is never injurious if the system be vigorous, and not exhausted.

Causes of Circulation through the Capillaries.

380. The force of the heart and of the arteries, if these last exert any, is not expended till the blood passes beyond the arteries.

381. The blood is also drawn on by the movement of the blood in the veins.

Some think the capillaries exert a force by alternate contraction and relaxation, like a great multitude of hearts beating slowly. Some think

that the action of the capillaries is owing to their elasticity. However this may be,

382. The size of the capillaries is most evidently under the influence of the mind, the nervous system of organic life, and of course, the general health of the whole system.

This is proved by the paleness and flush of the skin varying with every sudden emotion of the mind. By the rich healthy crimson which overspreads the robust cheek when presented to the northwest blast, and by the pallor of general debility, as common expressions prove, for we daily hear "the flush of health," "sickly looks," &c. All this being produced by an increased or diminished size of the capillary bloodvessels of the part considered.

383. All the remarks made upon the arteries, apply with tenfold force and importauce to the capillaries, and they need not be repeated, but should be re-read.

Causes of Circulation through the Veins.

384. The blood in the veins is doubtless urged on by some force received through the capillaries, and on account of their valves, are singularly benefited by exercise and rubbing.

Rubbing should be used with little force against the valves, as they are thin.

385. The position of the body also assists the return of the blood through the veins.

When a person has been standing much on the feet, the blood is apt to force its way back, through the valves, distending the veins, &c. This is remedied by bandaging the parts liable to injury, but not so tightly as to check the flow of blood through the deep arteries. Placing the feet in an elevated position will facilitate the return of the blood. Hence those who stand much on their feet, are very apt to throw the feet upon the table, window, stool, &c., as soon as opportunity offers.

386. In this connection it may also be mentioned, that if it be not desirable to have the blood circulate through any part, for instance, if any part be wounded, or inflamed, it should always be elevated, as then the blood flows to it with greater difficulty, while it flows away with greater ease.

387. The veins of the head are not furnished with valves.

Hence it is the evident intention of nature that the head should be supported above the heart, otherwise the blood "settles" back into the head. Particular care should be taken, to have the head elevated during sleep, in case of children, those subject to fits, convulsions, apoplexy, students, and all those subject to irregularities of the nervous system.*

388. The blood is also drawn through the veins by the "suction" of the heart and inspiration of the chest, though the amount of force exerted is uncertain.

389. The veins as seen in the hand, open into each other almost at right angles (Fig. 107, Lith. Pl. 4, Fig. 1), by which the blood is moved on with greater rapidity, as illustrated by Fig. 111.

Fig. 111.

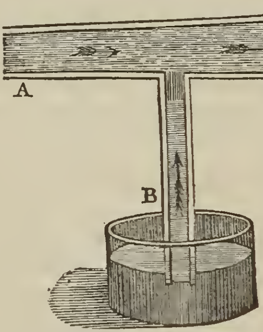


Fig. 111.—A, C, a tube, through which the fluid passes from the small towards the large extremity, drawing the water up from the bowl B, through the tube opening at right angles into A, C.

Conclusion.

390. By all these causes, the blood is moved through the system, with almost incredible velocity, and without the slightest jar or disturbance.

* As before shown, there is no danger of a person becoming "crooked."

Indeed, the movement of the blood takes place with such quietness, that almost every one overlooks the wonderful action constantly going on in his system. If the amount of blood in the system be computed as 20 pounds, it will be between the extremes of eight and forty pounds, which different persons have taken, as the amount, without, however, any sure means of knowing. It has been shown, that at least four pounds per minute, is thrown out by each heart. In five minutes, therefore, an amount equal to all the blood in the body, will be thrown out by the hearts. But all the blood in the system, is not in active motion. If a frog's foot be examined under a microscope, the blood will be seen motionless in some vessels, while in neighboring ones, its motion is almost as quick as lightning.

If it be computed, therefore, that one-fifth of the blood in the body, viz., four pounds, is in active circulation, it will be sufficient, and it will follow, that in one moment's time, the blood can run through the entire circulation. This is not merely speculative; experiments have been tried upon horses. A substance called ferrocyanite of potash, which is very easily detected in blood, was injected into the jugular vein of the right side of the neck, and an opening made in the Saphena (great vein of the hind leg) vein, and the flowing blood caught in different bowls, every five seconds. In the fourth bowl, the ferrocyanite of potash was discovered. That is to say in less than twenty seconds, the blood had passed down to the right heart, thence to the lungs, back to the left heart, then down as far as the knee, perhaps the foot of the horse, before it turned back into the veins, to make its exit. Other similar experiments prove conclusively, that one minute is not required for the blood to circulate through the entire system. Hence the perfection of the system; for the blood almost flies round and round in its rapid circuit, distributing its riches to every needy part, equalizing the temperature, by warming those parts which are cool, and cooling those parts which are warm, instantly removing any waste substance, and transporting it where it shall be cast from the body, in one form or another. Were a volume to be filled, the wonderful action and effects of the circulatory system, could not be told.

CHAPTER III.

THE RESPIRATORY ORGANS.

391. It has been clearly shown, that the food taken into the system is in part composed of the same ingredients, as various articles, which every experience proves, are capable, under proper circumstances, of producing heat. One of the most important of these circumstances, is, the presence of pure air. A candle would not burn in the stomach or blood-vessels, and the most intensely burning fire depends upon a draught of air, and goes out as soon as entirely deprived of it.

392. The greater the quantity of air, and the more forcibly it is brought in contact with burning substances, the more rapidly do they burn, and the more heat do they produce. Since, then, the production of heat depends on the action of the air upon the heat-producing object, the blood must be acted upon by the air; and from what is known of other things, it might be inferred, that the greater the quantity of air acting on the blood, the greater the amount of heat produced.

393. The respiratory, or breathing apparatus is, therefore, required for the purpose of exposing the blood to the action of the air.

Its great utility may be judged from the fact, that the blood is subject to the action of the air in the lungs, at each circulation. That the action of the air upon the blood is like its action upon other substances when they produce heat, may be inferred from the fact, that the blood returning from the lungs to the left heart, is warmer than the blood entering the lungs.

394. Three classes of organs are necessary to accomplish the desired object. 1st. An apparatus to receive the air. 2d. An arrangement of organs for circulating the blood in

such a manner, that it shall be extensively acted upon by the air. 3d. An apparatus for removing and replacing the air, the good qualities of which, have been exhausted by use.

There are, therefore to be four sections in this chapter.

SECTION 1.—*The Air Passages.*

395. On its way to act on the blood, the air naturally enters the nose first. This has been prepared for warming it before it enters the more sensitive windpipe.

Hence, one reason why the passage is narrowed by the turbinated bones, and the contraction of the muscles, which partially close the opening into the nostrils. Hence, also, the reason why diseases of the lining of the windpipe and the nose, are so similar; for as they were intended to serve the same purpose, viz., the passage of the air, they have been constituted in the same manner; whether their diseases are similar on this account, or because similar nervous influences are exerted upon each, is not known.

396. The throat is a passage, common to the air passing through the nose or mouth; an opening from it leads into the upper and back part of the windpipe. This opening is closed by raising the windpipe, till the edges of its opening are brought against what is called a valve, or the epiglottis. It is a piece of cartilage, shaped like a leaf. It is connected by one end to the inner and upper edge of the front of the windpipe. Its upper surface, for two-thirds of the way, is attached to the under part of the back portion of the tongue. The remaining portion projects into the throat, in an upward and backward direction, and is easily felt by passing the finger over the tongue.

397. The windpipe is composed of three parts. The first, called the larynx, the large part in the upper and front region of the neck, called, sometimes, Adam's apple. It

appears large, externally, but from its structure, (hereafter to be considered,) its passage is quite narrow.

398. The second part, called the trachea, is a straight tube, two thirds of its circumference formed of cartilaginous hoops, closed behind by membrane. The rings are connected with each other by elastic yellow membrane. The trachea reaches from the larynx to a little below the upper part of the breast-bone, where it divides, to form

399. The third part, called the bronchii. They are merely the divisions of the trachea, and formed like it. They are found in the chest, upon either side of the centre (Fig. 112).

Fig. 112.

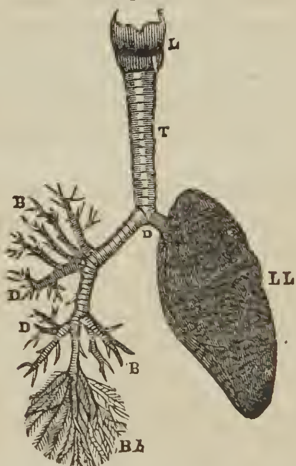


Fig. 112.—L, Larynx. T, Trachea. D, Bronchii. L, L, Left lung.

A good idea will be formed of them, if the leaves be stripped and the wood removed from the bark of a tree. The hollow bark would represent the windpipe.

400. The entire length of the windpipe, commencing at

the throat, is lined by a very delicate membrane, called mucous membrane. When it arrives at the smallest divisions of the windpipe, it is most beautiful. At the extremities of these divisions, it is formed into little pouches, cells, vesicles, or sacs (Lith. Pl. 3, Fig. 2). The largest of these are not larger than a mustard-seed; but they are so numerous, that one author has computed there are not less than 180,000,000 in the lungs of one person.

401. These are the receptacles of the air. Into these it is drawn, and from these it is thrown out. The entire arrangement is for the purpose of causing the air to act on a great extent of surface, and if the surface of so many millions of cells be computed, it will not probably fall short of that so frequently made, viz., that there is more surface in the air passages than upon the whole body. The added capacity of so many cells must be comparatively very great, and the cells, taken as a whole, will occupy much more room when full than when empty.

SECTION 2.—*Circulation of the Blood about the Air Passages.*

402. There are two circulations. One, the grand circulation usually spoken of, the purpose of which is to bring the blood just returned from the body, in contiguity with the air. The other is for the purpose of nourishing, &c., the air-tubes, bloodvessels, &c.; and is produced by the action of the left heart, which sends the life-giving blood to all parts of the body.

403. It has been seen, that the blood coming into the right heart from all parts of the body, is thrown out through a vessel which immediately divides; one branch accompanying the windpipe on one side, the other branch passing to the other division of the windpipe.

404. As often as the windpipe divides (Lith. Pl. 3, Fig. 2) the bloodvessel accompanying it divides in a similar manner, till at last the minute divisions of the bloodvessels reach the air-cells, when they pour their contents into the capillary

bloodvessels which form upon the sides of the air-cells a most beautiful network (Lith. Pl. 3, Fig. 3).

405. From this network, the blood passes into the veins to return to the left heart. They accompany the divisions of the windpipe, uniting at the junction of the branches of the windpipe—two veins, however, being found by the side of each branch, and two veins from each side returning to the left heart.

Section 3.—*Inhalation and Exhalation of Air.*

406. The air-cells are filled upon the principle that gravitation causes air to rush into any cavity (Fig. 113).

Fig. 113.

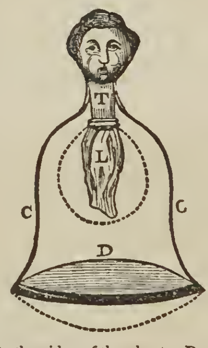


Fig. 113.—C, C, represents the sides of the chest. D, the diaphragm. T, trachea. L, lung. D is never in reality drawn down as far as the dotted line below; but if it were, and as far as it moved, it would tend to produce a vacuum if the air were not pressed down through the mouth and into the bag L, which is distended to the dotted line.

407. The air-cells are situated in each side of the chest, and communicate with the air through the windpipe and nose, or mouth.

408. The chest is composed of the back-bone, the ribs

and their cartilages, and the breast-bone as a framework (Figs. 1, 2, 3). The spaces between the ribs being closed by muscles, called intercostal (between ribs), and the bottom of the chest by the diaphragm (Lith. Pl. 1, Fig. 4).

409. The ribs are connected to the back-bone by joints which will allow them to move up and down,

Which motions increase and diminish the diameter of the chest, as may be perceived by placing the hands upon the chest and raising the ribs—as when the breath is drawn in.

410. The ribs are raised by the great number of muscles which connect between the ribs and the shoulders and back-bone (Lith. Pl. 2, Fig. 1), and by the contraction of the muscles between the ribs.

Of these there are two layers, crossing each other (Fig. 114). The dotted lines represent how they might pass; but as a muscle can only contract for about one-third its length, a muscle like L could only raise the rib through one-third the intercostal (between rib) space; while the contraction of the muscles *m*, can cause the ribs to almost touch.

Fig. 114.

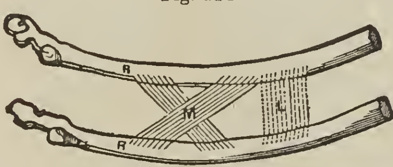


Fig. 114.—R, R, ribs. M, transverse muscles. L, the direction they might have, but with decided loss of motion to the ribs.

411. When the ribs are raised, it is evident that the muscles passing from the ribs to the pelvis must be relaxed.

412. The diaphragm is tendinous in its central part, and at the portion beneath the heart is capable of very little motion. Upon either side of this, are found the arches of the diaphragm. The sides of these are muscular. When they contract the arch of the diaphragm is diminished or lowered, and the length of the chest is increased.

413. It is evident, as before shown, that the parts below the diaphragm must be pressed upon, and indeed moved down. This can only take place if the sides of the abdomen yield, to wit, if the muscles relax. Hence the same thing is necessary that the ribs may be raised, as is necessary that the diaphragm may be contracted.

414. Raising the ribs and contracting the sides of the diaphragm by enlarging the capacity of the chest, tends to cause a cavity in it, and the air rushes through the mouth or nose and windpipe, into the air-cells.

The more extensive the motions of the ribs and diaphragm, the greater the quantity of air entering the air-cells.

415. For the same reason that the air tends to enter the air-cells, the blood will flow more rapidly into the network about the cells, when the ribs are raised and diaphragm lowered.

416. It seems then, that to say "drawing in the breath"—as is the common expression—is not quite correct; a person merely raises the ribs and contracts the diaphragm, and the air is instantly pressed or pushed into the air-cells by its own weight.

417. There are two causes in action, to throw the air out of the air-cells.

418. In the first place, there is a substance filling what would otherwise be spaces, between the divisions of the windpipe and between the air-cells. It is called the parenchymatous substance of the lungs. Its great peculiarity, is its elasticity.

Some suppose its apparent elasticity is in fact owing to a contractile power of some part of the sides of the air-cells.

419. What is meant by its elasticity is perceived, if a person attempt to fill the air-cells by blowing into the windpipe, which with the lungs has been removed from any animal. The substance of the lung, on account of its elasticity, presses upon the sides of the air-cells to such a degree, that it will be very difficult in some animals to fill them out; and the instant the force which fills them ceases to act, the pressure upon the sides of the air-cells throws the air out of them.

420. It may be observed, that when the air passes into the lung, it must probably overcome the elasticity which is continually acting, though it may be, that the elasticity of the substance of the lung is so dependent

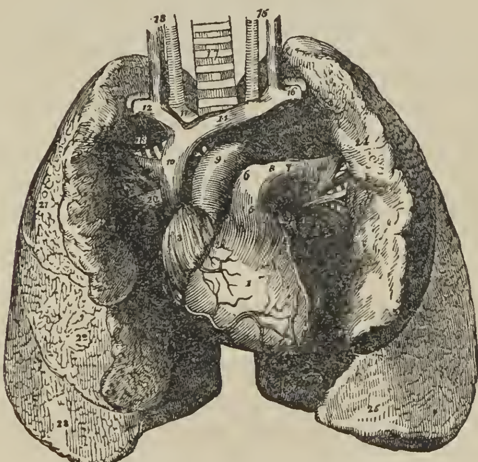
upon the nervous system that it can be increased and diminished, if not entirely removed, as the case may require.

421. In the second place, there are two classes of muscles, which co-operate with the elasticity of the lungs in throwing out the air ; one class acts upon the ribs, to draw them down ; the other class presses upon the organs of the abdomen, causing them to press upon the diaphragm and move its arches upward.

It is evident that the muscles which raise the ribs, as also the sides of the diaphragm, must relax when the air is thrown out.

422. To understand perfectly the manner in which the air is caused to pass in and out of the lungs, it must be noticed that the air-passages and cells, and air in them, together with the substance of the lungs, the bloodvessels, and the blood in them, fill the sides of the chest in such a manner that the outside of the lungs is constantly in contact with the inner surface of the chest and the upper surface of the diaphragm.

Fig. 115.



423. That no harm may be produced by the contact, the inside of the ribs and muscles between, is lined with a beautifully delicate membrane

called pleura costalis (rib). It is reflected, as the expression is, upon the roots of the lungs, and covers them, being then called pleura pulmonalis (lung). The surface of that which covers the lung is in contact with the surface of that lining the chest and the diaphragm. To prevent adhesion, and allow motion upon each other without friction, the pleura is constantly moistened with a glairy fluid called serous, formed and removed by the action of the pleura.

424. It will now be understood, that as the lung perfectly fills the chest, the instant the ribs begin to rise or the diaphragm is lowered, there is a tendency to a cavity between the chest and lungs, which the air prevents from existing, by pressing into the lungs and filling them out as rapidly as the chest enlarges. As soon, on the other hand, as the muscles begin to contract, which draw down the ribs and press upon the abdominal organs, it would seem that the lungs being in contact with the ribs would be pressed upon ; but upon a moment's reflection it will be observed that the elasticity of the lungs will not, in ordinary cases, allow any pressure to take place, as it causes the lungs to contract and diminish in size as rapidly as the chest follows. The lungs, therefore, are so nicely adjusted, that it is only in very forcible breathing that they are pressed upon at their external surface ; but they are suspended, as it were, in the chest, in most delicate contact with its surface, the forces which are acting upon them from all directions being so justly balanced, that the lungs seem sustained in the midst of the chest without support from any particular point. The roots, as they are called, of the lungs, are loosely connected with the back-bone ; but they do not, more than the windpipe, sustain the lungs in any material manner, for parts of the lung are above them. The lungs are supported by the resilience of their substance, the contraction of the muscles, and the pressure of the air.

SECTION 4.—*Action of the Blood and Air upon each other.*

425. Three evident effects are produced upon the blood in the lungs. Its color is changed from a purple to a bright red, its temperature is raised, and it is diminished in quantity.

Doubtless other effects are produced, but about these there is no dispute.

426. The degree of effect depends upon the quantity and quality of the blood, upon the constitution and condition of the lungs, upon the health of the body generally, and upon the quantity and quality of air to the action of which the blood has been subjected in the lungs.

427. *The quantity and quality of the blood.* Both these things depend upon the quantity and quality of the food and drink, upon the exercise a person has taken, and the fulfilment of the duties of the other organs.

a. It has heretofore been shown, that certain articles of food were used to warm the body. If these are scarce in the bloodvessels, it could not be expected that an abundance of heat would be produced in the lungs. Hence why a person feels warmer for eating heartily in cold weather.

b. The quantity of drink affects the quantity of blood in the vessels, and of course, other things being similar, will affect the amount of substance adapted to produce heat passing through the lungs in a given time. Hence in cold weather there should be less water in the blood than in warm; consequently there is little thirst in winter, and those who without thirst drink largely of tea, coffee, &c., suffer more from the cold. Nature also calls on the kidneys to relieve the bloodvessels of a part of their fluid, when the system is exposed to the cold.

c. The exercise a person takes does, of course, by wearing out the system, affect the quality and quantity of the blood; but whether in such a manner, other than by increasing the rapidity of the circulation, as to increase the amount of substance concerned in producing heat in the lungs, is not known. The more actively a person exercises, the warmer does he become; but there are three ways of accounting for it—either because the circulation is caused to be more rapid, because as the parts are decomposing, heat is produced, or because the wearing or exercised parts supply to the blood an increased quantity of material, by which, in the lungs heat is produced.

d. The fulfilment of the duties of the organs will have a striking effect upon the quantity and quality of the blood. As just illustrated, the kidneys sometimes diminish the quantity of the blood surprisingly, without in the least affecting those parts of its ingredients concerned in producing heat; while on the other hand, by not performing their duty, they may allow the fluid of the blood to increase till there is nothing like

the proper quantity of heat-producing material passing through the lungs in a given time. The heat-producing material, or the fuel, as it may be called, of the blood, may be removed by some organ, for instance the carbon by the liver, and the lungs thus receive a less quantity than they ought, &c.

428. The activity of the heart greatly influences the quantity of blood which in a given time passes through any organ.

429. The lungs of different persons constitutionally vary in respect to size, the capacity of the bloodvessels, the ease with which blood circulates through them, the degree of nervous energy exerted upon them, &c., while the condition of the lungs varies under the action of all the causes of health and disease.

430. The health of the body generally will, by the influence of the nervous system, produce a most important effect upon the changes taking place in the lungs.

A person who is exhausted, therefore, will not be able to warm himself in a perfect manner, and must therefore be careful of exposure and protect himself by an abundance of clothing. People soon feel chilly if they are exposed when exhausted, and readily "take cold."

431. That the quantity and quality of the air have a great influence upon the changes the blood undergoes in the lungs, is evident from the changes taking place in the air while in the lungs. To understand these, it is necessary first, to consider the constitution of the air; second, the manner in which heat is usually produced.

432. Air is composed of two simple elements, and one compound element in very small proportion. About eighty parts in a hundred of the air is composed of a kind of air or gas called nitrogen, a simple element, and apparently of no use except to dilute the oxygen, the name of the other simple element, a gas or air composing about twenty parts in a hundred of the atmosphere. The compound element is also a gas, called carbonic acid, and forms about one part in two thousand of pure air.

It is compounded of oxygen and carbon, a simple element or sub-

stance which composes the greater part of coal, and gives to it its chief characteristics.

433. When the air leaves the lungs, it is very different; instead of twenty parts in a hundred, it contains but sixteen of oxygen, and contains nearly four parts of carbonic acid. It is very full of moisture, as may be seen by breathing upon glass, &c. Its proportion of nitrogen has not changed in an appreciable degree.

If a person blow the air from the lungs through lime-water, it turns to a milky color, and if it be allowed "to stand," a chalky substance will be seen at the bottom. This is found upon examination to be formed of carbonic acid and lime, the same as limestone, marble, &c. The lime was in the lime-water, and the carbonic acid must have been in the air breathed from the lungs.

If a person apply his mouth to the mouth of a bell-glass, bottle, or decanter, the bottom of which is wanting or has a hole broken in it, and then push the bottom a short distance into a pail of water, he can draw all the air in the bottle into his lungs, from which he can breathe the air back into the bottle. This must be so held in the water that it shall follow up into the bottle as the air is drawn out, and when the bottle is again filled with air, it must be held quite steady, with the mouth yet applied to it and the bottom yet in the water. In the meantime, let a match be lighted, and when it is burning well, remove the mouth and drop the bottle a little, for instance, an inch into the water, and thrust the match into the mouth of the bottle, when, if the experiment have been well managed, the match will instantly go out, showing that the air is so changed in the lungs that a match will not burn in it; and what is exceedingly surprising, a person cannot draw the air into the lungs and throw it out so quickly that the match will burn in it. To know why this is, we must, in the second place, consider how heat is produced.

434. It is found by experiment, that when certain substances unite together they always produce heat.

This is explained by supposing that the substances, when separate, contain more heat than when, united, they are able to retain. For instance, when hydrogen and oxygen unite to form water, they produce heat, each having a certain amount of heat which it retains while it is in a separate state; but when they unite, they lose their power of retaining as much as they could when separate. On the other hand, if water be

separated into oxygen and hydrogen, they will require a certain amount of heat more than they had when forming water; and the required amount they will take or draw from any thing around them which is not stronger to retain than they are to obtain.

435. When carbon and oxygen unite to form carbonic acid, heat is produced upon the same principle; and on the other hand, coldness is caused when carbonic acid is changed into carbon and oxygen; and though there is scarcely a change taking place in nature, that is not attended with a change of temperature, yet heat is usually and chiefly produced by the formation of water and carbonic acid.

436. This will be illustrated by observing how a candle is burned, and for simplicity, one particle of fat may first be taken. It is composed of oxygen, carbon, and hydrogen, closely united. In order to separate them from each other, a lighted match is held near to the particle of fat, as the heat of the match has a tendency to separate the particles of any substance. When the components of the fat are separated to a given distance, they will not return to their former condition; but the oxygen and hydrogen have, by nature, so strong a tendency to unite, that they will do so, and thus form water, while the carbon will be left by itself, in the form of soot, lampblack, or coal, if there be no air about it; but if there be, the oxygen of the air will unite with the carbon, producing carbonic acid, and thus the fat will be burned up. The heat which is produced by the burning of the first particle will act upon the second particle, and separate its oxygen, hydrogen, and carbon, which will unite with each other and the oxygen of the air, form water and carbonic acid, thus producing heat, which acts on the surrounding particles, which pass through the process, until, at last, particle after particle, the whole candle is burned.

437. A similar process takes place when wood is burned, for wood is composed of carbon, hydrogen, and oxygen, with some other articles, which form the ashes. This is proved, by noticing what a quantity of vapor rises from a chimney of a cold morning when the water from the wood is condensed; also, how much water will trickle from a stove-pipe, when so long as to condense the vapor produced by the burning wood. If the contents of the stove-pipe be caused to pass through lime-water, the same appearance is exhibited as when a person breathes through it, showing that carbonic acid exists in the pipe, and is formed by burning the wood.

438. If, however, the air be not admitted to the burning wood, as in an air-tight stove or in a coal-pit may be the case, water only will be

formed, and the carbon will remain behind in the form of coal. If a coal-pit be noticed of a cold day, a large amount of vapor will be seen rising from it, owing to the water formed from the wood finding its way out. It is not certain, however, but a small portion of the oxygen of the wood may unite with its carbon, and it may be that a small quantity of the oxygen of the air unites with the hydrogen of the wood.

439. It is certain that the larger the quantity of air present, the more rapidly will any thing burn; for a strong draught causes wood, coal, and the contents of a lamp to burn with greater energy and corresponding heat; and that this depends upon the oxygen of the air, is proved by the experiment already mentioned with the match, bottle, &c. It follows, therefore, that the greater the quantity of oxygen acting on any article used as fuel, the greater is the effect.

440. *Every argument proves that the greater the quantity of oxygen acting in the lungs, in a given length of time, the greater the amount of heat produced, other things being equal.*

a. The food eaten with the evident intent that it shall warm the system, is such as contains oxygen, hydrogen, and carbon.

b. The various parts of the body which are worn out or decomposed by exercise, which is productive of heat, contain carbon, oxygen, and hydrogen, and at such times there is a more active circulation of blood through the lungs, and breathing is more rapid.

c. In summer the liver is more active, in proportion, than in winter, and removes more carbon; evidently because, if the carbon should be removed by the lungs, heat would be produced when it is not needed.

d. The substances which pass from the lungs, are such as would result from a combination of the oxygen of the air with the constituents of the blood; and there is a corresponding disappearance of the oxygen which entered the lungs.

e. Whatever facilitates the entrance of blood into the lungs, has an equally good effect upon the admission of the air.

f. In warm weather, the air is correspondingly rarefied, and only a small quantity of air enters the lungs at one inhalation of the breath; while in cold weather, a large quantity of air enters the lungs. In cold weather, the air is expanded after it is received into the lungs, as any one can test, by placing the hands upon the sides, and inhaling the cold air suddenly; the chest will be felt to enlarge afterward. By this means, the air is brought more forcibly in contact with the inner surface of the cells, and produces a more powerful effect upon the blood circulating

around them. In summer, the air being warm expands but little, and but little effect is produced; a most admirable adaptation of things to the necessities of man.

441. The next question would be, What causes the changes to take place between the blood and air? The answer would be, that the changes are either necessary, from the constitution of the blood and air, or they are under the control of the nervous system of organic life.

442. Again, it may be asked, Why does not the heat in the lungs, if produced by the action of the blood upon air, exhibit itself more distinctly? The answer is, that the blood moves through the lungs so rapidly, that the heat is removed from them almost as fast as produced.

443. Some think that very little if any heat is produced in the lungs directly; but that the constituents of the air unite with the blood in the lungs, and with it are carried into various parts of the body, where they serve the important purpose of producing heat, while the substances produced are brought by the blood to the lungs, from which they are removed when the air is expired; but all parties allow the lungs to be equally important. And when it is remembered how rapidly the blood moves through the lungs, the exceedingly great quantity of it passing through the lungs in the course of twenty-four hours, and that the blood of the entire body circulates through the lungs each time it visits the heart, the importance of these organs must be in a measure appreciated, as well as the consequence, in particular, of having them supplied with a large quantity of pure air. We may, therefore, now consider what will facilitate, and what will prevent the action of pure air in large quantities.

444. It is evident there must be some cause acting in the lungs, to cause the air to unite with the components of the blood. The nervous system of organic life is supposed to be the direct agent in this case; it therefore follows that,

445. The more healthy and vigorous the general health, the more active will be the changes taking place, between the air and blood.

If any portion of the lungs be diseased, there cannot be a free circulation of blood or air through the diseased part; from which it follows,

446. The more healthy the lungs, the greater the effect produced in them.

It sometimes, indeed frequently happens, that if some part of the lung

be diseased, the other parts perform their duties more actively, or the motion of the chest is increased, that the want of action in the diseased part may be compensated. For instance, in case of asthma, the shoulders frequently grow out. When a person is affected by consumption, a peculiar stoop is observed, not like that of negligence, but the "consumptive round shoulders."*

In the next place, it must be evident that if the bloodvessels of the lungs are too much filled with blood, the air-cells will not be allowed to distend with air; it therefore follows that,

447. A proper circulation of blood through the lungs is important, and all causes which tend to derange it, must be injurious.

e. g. When a person has taken cold by exposure of the skin, and the blood has been driven inward, there seems to be a fulness of the chest, and the breath is inhaled with difficulty, and any thing which restores the circulation, gives immediate relief.

But as the inhalation of the air depends upon the movement of the chest and depression of the diaphragm,

448. Whatever checks the elevation of the chest, or depression of the diaphragm, prevents a perfect action of the air upon the blood; and whatever assists the elevation of the chest, and depression of the diaphragm, increases the action of the air and blood upon each other.

Every bandage or snugly fitting article of dress must be injurious, for if upon the chest they prevent its movements, if upon the abdomen they prevent the distension of its sides, without which the diaphragm cannot contract, as has been shown.† Much worse must any thing be which lessens the size of the chest, which can readily be done, especially in early life, for the ribs yield at their joints with the back-bone, and though

* Such being the cause of the round shoulders of consumption, how erroneous to attribute the disease to the deformity, and how foolish to attempt to cure a person, or benefit him, if consumptive, by making him straight, when nature has made him become crooked to lengthen his life. While the disease remains, it would be a misfortune to change his form.

† How absurd the pretensions of some, to improve the lungs by any articles producing pressure on the abdomen, fictitiously called supporters, or by the use of any shoulder-braces, with bandages girding the abdomen, or indeed applied in any way.

bony, they are *themselves pliable,* while the cartilages which connect them with the breast-bone are very easily bent: thus are produced the most pity-causing deformities (Fig. 116 and Fig. 117). The movements of the diaphragm are especially prevented by any fulness of the abdominal organs, as it distends the sides of the abdomen, and it is difficult for the diaphragm to distend them still more, as it must if it contract. Hence a person is troubled for breath after eating very heartily. The elasticity of the lungs is also such, at times, as to be very difficult to overcome; and whoever will endeavor to fill out the lungs of an ox, or even a calf, will appreciate better than in any other way the power required in some cases. On the other hand, a perfect freedom from the stricture or weight of clothing, and much exercise of the respiratory muscles, must supply the lungs with a sufficient quantity of air. Hence the importance of singing, reading aloud, going up and down hill, indeed, doing any thing which shall exercise the muscles of the chest and diaphragm. It must be evident the chest cannot be easily or greatly elevated, nor the diaphragm contracted, when a person stands perfectly straight, for then the muscles of the abdomen are made comparatively tense, and it will be difficult to distend the sides of the abdomen.* A singer is observed to bend forward a little when the breath is taken in.

Fig. 116.

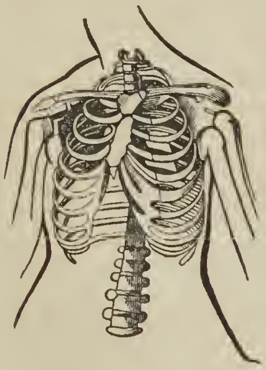


Fig. 117.

* Again, is seen the folly of wearing supporters, shoulder-braces, or any thing which shall keep a person perfectly straight.

But the question is not merely, how may the capacity of the lungs be increased, but rather how may a large quantity of air be *frequently changed* in the lungs; from which it follows that,

449. Whatever facilitates the expulsion of the air from the lungs is advantageous, while any thing that prevents this is injurious.

The contraction of the abdominal muscles, assisted by that of some o the muscles upon the back, draw down the elevated chest, provided the back be not too much curved; and the straighter it is, the more powerfully will the muscles act; for a muscle is always more efficient when it first begins to contract, than when contracted to almost its entire degree. Hence a singer will straighten himself, that the breath may be thrown out with greater force. In order, however, that the muscles of the abdomen may have their greatest force on the diaphragm, the abdominal organs must be more or less full; as, if they are nearly empty, the muscles will contract in a straight line, from the edge of the ribs to the hips, without pressing with force upon the abdominal organs; but when they are full, the muscles are distended outward, and when contracting, necessarily press the organs inward, and exert a force upward against the diaphragm. A reasonable fulness of the abdominal organs, and a reasonable erectness of form, is to be recommended; but a *frequent change of position* is the best rule of life. When the abdominal organs are full, a person need not be as erect as when they are empty. Exercise of the muscles of expiration will, of course, render them more effective.

When air is taken into the lungs, it expands if it be cooler than they are; and the greater the difference of temperature, the greater the expansion, and the greater the expansion, the more forcibly is the air brought in contact with the sides of the air-cells, and the greater the effect produced upon the blood which circulates about them. Whence it follows that,

450. The colder the weather, the greater the changes of the blood and air in the lungs.

Hence cold air is found to be most bracing; hence one reason why morning air is more effective than that of any other part of the day. These things show the wise adaptation of all things to each other, and inspire a confidence in the laws of the Creator that is very gratifying.

But the utility of the air in the lungs depends upon certain of its parts uniting with the components of the blood; it is not, therefore, the

quantity of the air merely, but also the quality which must be considered; and it has been proved, that the air coming from the lungs is not suitable to be received again; and as a large quantity is used in the lungs in a very little time, it follows that,

451. All rooms should be perfectly ventilated, by having communication with the grand reservoir—the atmosphere surrounding the earth.

This should evidently be more carefully attended to during the night than during the day, as then the opening and shutting of doors, and the fires of cold weather, will tend to purify or change the air in a room. During the night, also, the state of repose prevents the lungs from receiving as much air as while a person is stirring during the day; and the comparatively inactive state of the nervous system prevents, to a degree, those changes which take place during the day. These principles are most inexcusably neglected by many of those who have the charge of constructing public buildings, and by nearly all, in the arrangement of their sleeping apartments, which by some persons are supplied with double windows, and every chink or cranny closed as securely as if the air, our greatest blessing, were our greatest enemy.* But experiment and accident have proved that the carbonic acid breathed out from the lungs is very poisonous when used in very small quantities. So small a proportion as 10 per cent. will destroy the life of animals, and many human beings have lost their lives by going into wells, tombs, and other places where it existed. The burning of most articles produces more or less of it; coal being carbon, produces a great deal when burning, and a pan of coals placed in a chamber has produced so much as to destroy life.† If a grate do not draw, the gas is likely to pass into the room without causing any smoke—a great cause of headaches, &c.

* In regard to pure air and water, unadulterated by tea, coffee, &c., the old adage seems true, "Nothing cost, nothing worth." If air could be monopolized and sold by the gallon, its value would soon be appreciated.

† When a person is injured by such a cause, place his feet and hands in warm water, rub him briskly, and apply cold cloths to his head, and produce artificial breathing. This is done by pressing upon the chest and abdomen, and then removing the pressure suddenly, when the elasticity of the chest and the lungs will inhale a portion of air. The pressure and removal of it must be made at such intervals as to imitate, as near as possible, common breathing.

It seems, therefore, that there is not any particular size of chest that is desirable, but that

452. A healthy state of the body generally, with active exercise of all parts of the body, but particularly the muscles of inspiration and expiration, and ventilated apartments, are the chief things which conduce to the perfect action of the air and blood upon each other in the lungs.

And as it has been seen, that one of the chief, if not the chief duty of the lungs is to produce heat, it follows,

453. If a person would be warm, he must preserve his general health, take exercise, and breathe pure air.

It is to be inferred that a person will sleep warmer, the coldest night in winter, with his apartment ventilated, which cannot be done perfectly except there be communication with out-doors. Especially during the night will a person be kept warmer and be in less danger of taking cold, if a sleeping apartment be ventilated, not in such a manner that a draught of air shall come upon a person, but at the same time perfectly.*

* A window may be raised with safety, if an outside or inside shutter be closed, or a wide board placed against the casing a little distance from the sash. If the upper sash be lowered and the lower sash raised, the change of air is more perfect ; but a board or shutter must be so placed in respect to the upper sash, that the air cannot sweep across the room, as it will be inclined to do, and striking against the opposite wall, fall downward, producing a current. The position of the bed should be such that a person cannot be affected by such currents ; they will be produced across a large room in many cases, and if the bed be against or very near the wall, a person in it will feel the current almost, if not quite as sensibly, as if near the window.

CHAPTER IV.

THE VOICE.

454. Speech is produced by the combined action of some of the first and some of the second class of organs. The principle upon which they act is very simple—merely this:

455. Air, when forced through an opening or passage, will produce sound, viz., will be thrown into such waves or vibrations that the nerve of the ear will be acted upon.

456. The character of the sound will depend on the dimensions and form of the opening or passage, the nature of the substance in which the opening exists, the degree of force with which the air passes through, and the kind of air.

SECTION 1.—*Expulsion of Vocal Air.*

457. The breathing apparatus is perfectly adapted to perform a part in the production of speech. The lungs are admirable reservoirs for containing air, which can be forced out by the expiratory muscles with any degree of suddenness.

For, by closing the open part of the windpipe, the air can be forced against the valve, when by quickly dropping the windpipe, a larger or smaller portion of air will gush out.

458. Whatever, therefore, is for the good of the respiratory apparatus, benefits a person in respect to the voice, so far as throwing out the air with force is concerned.

459. That the respiratory muscles may be effective in

producing speech, they must be under the direct control of the mind.

They therefore belong to the class of mixed muscles, viz., those which in health and ordinarily, contract either voluntarily or involuntarily.

SECTION 2.—*Modifiers of Sound.*

460. The passage through which the air passes, in its emission from the lungs, producing sound when forcibly emitted, may be considered in four respects.

461. 1st. There is an arrangement near the top of the windpipe, below the valve against which the windpipe is drawn to close itself, within the larynx, by which the air is acted upon when any tones are produced.

When a person makes the sound of A, the windpipe is first raised and closed, the expiratory muscles contract and force the air upward; the windpipe is dropped more or less, and the air gushes out, producing such a sound as desired, because the apparatus within the larynx has been by the action of proper muscles, placed in that state which experience teaches to be necessary.

462. 2d. After the air has passed the outlets of the windpipe, it may be acted upon in the back part of the throat and its sound modified,

As will be appreciated by making the sound of the letter B. It is not full and prompt, but subdued, and with others of its class, called sub-tone.

463. 3d. The air may be obstructed, not at the windpipe, but in the front part of the mouth, and again allowed to pass on suddenly, producing a class of "whisper sounds,"

As when the letter F is spoken. All this class of sounds are called aspirates.

464. 4th. The character of each sound of each class is more or less affected by the structure, shape, and size of the

windpipe, the opening from it, the throat, the nose, the mouth, and as some think, the whole head.

The character of the voice is also affected by the capacity of the lungs and the structure of the chest; for if the volume of air in the lungs be large, and the chest firm and sonorous when struck, the voice has more tulness and resonance.

465. These things affect merely the richness, the fulness, and peculiar character of the tones of the voice, enabling us to readily distinguish one person from another by his voice, but not such as to ever affect in the least the understanding of the ideas expressed by a person. Nor can the form, shape, or size of any of these parts, except probably the upper part of the windpipe, be affected by a person's efforts.

466. As the arrangement of the larynx which affects the production of desirable sounds, is made by the action of muscles, so also is that of the throat and front part of the mouth. It would seem, therefore, that

467. The production of voice, to wit, the inhalation and exhalation of air, the closing and opening the windpipe, the modification of the larynx, throat, and mouth, is wholly dependent on the action of muscles which are dependent on nervous influence caused to act by the mind, on the reception of blood, and on the nervous influence of organic life.

All the rules, therefore, which apply to muscles heretofore considered, must apply to these, viz., they must be exercised—lightly at first—gradually increased, and never beyond the point of fatigue.

468. These muscles are made impulsive by the emotions, and in a certain sense may be considered muscles of expression. Hence, as heretofore shown, if a person would read or speak in a certain way, he must excite the emotions calculated to induce the desirable action of the muscles.*

* That the action of these muscles are in part involuntary and dependent on the state of the nervous system, is proved by the groans and cries of persons operated upon by the surgeon while they are under the influence of chloroform; and by the cries of sick persons, particularly children, such that the disease can by a skilful person be detected many times by the moans or piercing cries. That the voice may have expression (so also the manner), it will be well for the student not to devote so much time to imitating gestures (which to a degree is well enough), as to cultivating a power of calling up fervid emotions at will. And as

469. The state of the general health, the perfection of the blood—depending in its turn on the purity of the air—the proper digestion of the food, &c., &c., will influence the condition of the muscles.

470. But if the muscles be healthy and exercised, they must, in the next place, be properly exercised.

How to do this and why it is necessary, is easily explained. First, it is evident that words are made up of simple sounds, as in case of the word pen. Here is an aspirate p, a tone e, and a subtone n. Now there are quite a number of muscles, the harmonious action of which is required to make one of these sounds—and the harmonious action of these muscles is only obtained by long and assiduous practice. Without this, the sound is apt to be imperfectly made, will of course be indistinct, and produce quite a confusion when forming part of a word or sentence, perhaps cause the sense of the whole to be misunderstood.

471. The sounds of each of the different letters of pen, are spoken by the use of some of the same muscles, and by the use of some different ones. To combine the action of the muscles required when the *word* is spoken requires *very much* exercise, and ought not certainly to be attempted till the simple sounds have been mastered. But as speaking these sounds is learned in early years, it usually falls to the lot of a student or teacher to correct evils of long standing. To do this, the same course must be taken, as if a person were learning for the first time. They must be trained to act in harmonious perfection, when the simple sounds are spoken, and then trained to act harmoniously when simple sounds are combined. This is also the true course to pursue, when learning to speak a foreign language. Thus a child, when learning to read, should first be taught to pronounce simple sounds perfectly—the *sounds* of the letters, not the *names*. P, as usually taught to a child learning its alphabet, is a compound made up of the p sound and the

none but actors should wish to have the power of calling up the bad passions and emotions that sometimes live in the human breast, the student should assiduously cultivate all those emotions which ennoble man—which render him kind to his fellow-being; and his patriotism, not selfish, but true and intense—then will his living emotions control his whole action, manner and bearing, not less in his voice than otherwise; and that moving eloquence which is from the heart, will make an abiding impression. Thus was it rather than by "holding stones in his mouth" (though these minor things are not to be despised), that Demosthenes governed the turbulent spirits of Athens. Thus did Cicero compel the Forum to resound with applause.

sound of e—thus pe. These simple sounds, are usually called elementary; and according to Rush,* are thirty-five in number. They should be thoroughly learned by the beginner, whose time may without harm be spent upon that which is perfectly mechanical. Then they should be combined in all possible ways; not merely such as are found in a person's native language, but in any language; for thus a person will not only speak his own language better, but will have that control over his muscles which will enable him to speak any language fluently in a very short time.

472. A child should be taught to read by note, not by rote; for as the singer who is well exercised in every combination of notes, sings any new tune very readily—so will it be with one who knows perfectly the elementary sounds of speech, and their almost innumerable combinations.

473. If there be any defect of speech, such as stammering, lisping, &c., not owing to any malformation of the organs of speech, it can be removed by training the organs in the way above mentioned, and, in addition, throwing out, or as Rush terms it, exploding the simple and compound sounds. This is also an admirable way to gain strength to the voice, when feeble.† To do this, also a short time before speaking, gives flexibility to the organs of speech.

474. To speak easily, the feet must be kept warm, and the head and throat properly cool, and the air pure.‡

Section 3.—*The Larynx.*

475. The action of the muscles of the mouth and throat are so evident that it is not worth while to dwell upon them, as it is upon what is

* To the works of this distinguished ornament of the medical profession, the curious reader is with satisfaction referred for a complete consideration of this subject.

† It is evident, that feebleness of the voice is not all dependent on the state of the lungs, except they are very much diseased, and that a person may use the voice without injuring the lungs; but on the other hand it may have the effect to improve them and the whole body, for not only when speaking does a person *inhale* more air, but he swallows a considerable quantity in the frothy saliva.

‡ There is great danger of the throat becoming too hot as the blood circulates very actively through the muscles of speech. It will not therefore be prudent to dress the neck warmly, but on the other hand, it should be sponged outside, and gargled within with cold water.

usually considered the chief organ of speech, the larynx. Strange to say, the action of this part is not well understood. A view, however, of its structure, and conjectured uses, will not be uninteresting.

476. At the base of the tongue, a bone (Fig. 118) is found, called, from its form, the hyoid (U-shaped). From it a ligament and other connectives pass to a peculiar shaped cartilage, which forms the top of the windpipe, and the chief part of the larynx. It is called the thyroid (shield-shaped). Fig. 119 and Fig. 120. It does not pass round the back part of the larynx. A sufficiently clear view of the other three cartilages, is obtained from Fig. 119, and its explanation.

Fig. 118.

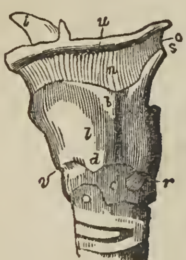


Fig. 119.

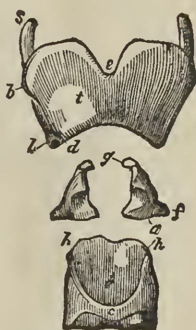


Fig. 118.—*u*, Hyoid bone. *n*, Membrane between *u* and *b*, thyroid cartilage. *c*, Cricoid cartilage.

Fig. 119.—*t*, Thyroid cartilage, front view. It exists in the front part of the upper portion of the windpipe. It is placed downwards from its position in the cut upon *c*. The sides of *t*, being outside of *c*, which is called the cricoid cartilage, it is narrow in front but wide behind *h*, *h*. *d*, The bottom of the arytenoid cartilage which is attached to *h*.

477. A view of the internal appearance of the larynx, is obtained from Fig. 121. A view of the vocal cords and their relations, is better obtained from Fig. 122.

By most it is thought, and it would seem correctly, that the tones

Fig. 120.

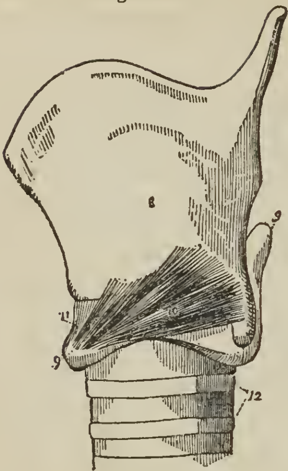


Fig. 121.

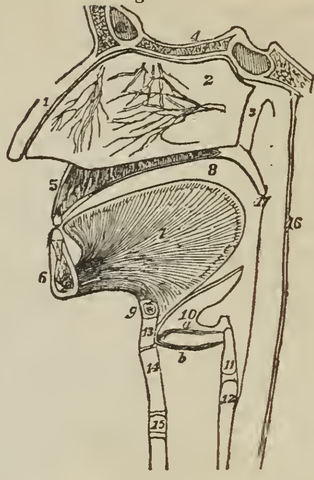


Fig. 122.

Fig. 120.—Side view of larynx. 8, Thyroid cartilage. 9, 9, Cricoid cartilage, 12 first rings of trachea. 11, Ligament stretching between 8 and 9. 10, Muscle, the contraction of which draws the back and lower part of 8 towards 9, thereby relaxing the vocal cords.

Fig. 121.—Section of face or one side of the division of the nose. 1, Nose. 2, Vomer. 3, Opening into the nostril behind 2. 4, Roof of nose. 5, Upper jaw. 6, Lower jaw. 7, Tongue. 8, Space between roof of the mouth and the tongue. 9, Hyoid bone. 10, Epiglottis. 11, Arytenoid cartilage. 12, 15, Cricoid cartilage. 13, Membrane. 14, Thyroid cartilage. 16, Back surface of throat and œsophagus. 17, Uvula or "hanging point in the mouth."

Fig. 122.—View from above, of the inside of the larynx. 3, 3, Vocal cords. 1, Space between them, through which the air passes out. 8, Thyroid cartilage. 9, 9, Cricoid cartilage. 2. Arytenoid cartilages. 7, Muscle which by contracting would tend to make the vocal cords lax. 6, Muscle which draws 2, 2, toward each other. 4, and 5, Muscles adapted to move the arytenoid cartilages, and thus act on the vocal cords.

of the voice, are produced by the air forced through the opening between the vocal cords, which are made more or less tense, as the case may require. But any philosophy yet advanced in respect to the particular action of these organs has objections.

CHAPTER V.

ORGANS OF EXCRETION.

478. The office of these organs is, to remove from the blood all substances unfit for use in the body.

It is a question, whether these useless substances exist in the blood, in the same form as when thrown out by the excreting organs, and are therefore merely separated from the blood, or are formed in the organs, in which case, both an action of separating and decomposing the blood and composing the substance, would take place.

It is, however, found that there are several of these organs differently constituted, removing their substances in different ways, and also removing different substances. It therefore follows that

479. There are different kinds of waste or useless substances in the blood, which require different arrangements for their removal.

Whether the necessary difference is found in the structure of the different organs, or in the structure and nervous influence exerted upon them, or in the nervous influence only, is uncertain. There are strong indications that the nervous influence can exert a powerful effect upon the character of the action of an excretory organ. For when by disease, any one is prevented from fulfilling its duties, some one, or all of the others will accomplish the task in its stead.

480. The number of excreting organs, could not, in the present stage of knowledge, be ascertained by any other means, than observation and experiment. It is thus learned there are five; the second stomach, liver, lungs, kidneys, and skin. The divisions of this chapter are, therefore, evident.

In the first place, however, it will be proper to make some remarks applicable to all.

All the excreting organs have other duties to perform, with the exception of the kidneys, which seem to be set apart for the especial purpose of excreting.

481. They all perform their duties by acting on the blood, which, of course, they must receive. But as the blood contains, at different times, different proportions of the material the different organs remove, so there must be a means of increasing the circulation through each organ, as the case may require, viz., the bloodvessels of these organs must be very susceptible of enlargement and diminution. In proof of which, witness the effect produced in the skin, how suddenly it is flushed or paled.

482. To increase or diminish, and to sustain and direct the action of these organs, they must receive the influence of the nervous system of organic life. The indirect influence of the mind is exhibited so evidently in many ways, as not to need illustration.

483. It is also very worthy of notice, that the blood necessarily contains a certain amount of useless substance, which does not, however, cause ill health, or any disturbance in the system, except it accumulate beyond a certain amount. On the other hand, its existence in the blood is necessary to the health of the system, as nature has constituted the excretory organs with the intent that they should have something to do, and they suffer without the intention is carried out.

Section 1.—*The Second Stomach, Colon, &c.*

484. It is one of the duties of these organs to remove continually, a large amount of substance from the blood, which in large quantities visits these parts, through large arterial branches with almost infinite subdivisions.

485. *a.* The first thing necessary is, that the substance to be removed exist in the blood. This is produced by exercise. Those, therefore, who are sedentary, are liable to inactivity of these organs, which exercise only will permanently remove. If a person say he has not time to exercise, let him remember he must be sick, and no medicine can save him.

486. *b.* In the next place, if the substance exist in the blood, it must be brought to the organ. This is favored by exercise and rubbing,

which quickens the circulation, and in this case, kneading the abdomen, and dashing cold water upon it; but more particularly exercising the muscles of the abdomen by talking, reading aloud, and all the causes of forcible breathing, are of great benefit.

487. *c.* In the next place, it is evident that if the brain be in constant action under the influence of a mind engrossed by business, or if the mind be perplexed or melancholy, the duties of these organs will b poorly fulfilled. It is useless to take medicine while the cause of derange ment exists.

488. *d.* Any cause, cold feet, fever, &c., which deranges the circula tion of the blood, will prevent the healthy action of the organs under con sideration.

489. *e.* As the excretion is removed from the blood, under the influence of the organic nervous system, all causes of exhaustion, either of body or mind, will have a marked influence upon these organs.

490. *f.* Every part of the body is influenced much by habit, and these organs as much as any. If they be in the habit of daily action, it is apt to be regular, but if a regular habit of these organs be broken up, it will be very difficult to preserve the pefect health of any part long.

491. *g.* This daily action is very much assisted by the use of such a portion of the waste food that these organs shall be reasonably distended by it, and stimulated to action.

492. *h.* The condition of the weather will have a great influence upon these organs. In warm weather the system does not feel as energetic to exercise, and of course there is not as much substance furnished as in cold weather. In warm weather the skin perspires very freely, and removes much that in winter will be removed by the second stomach, kidneys, and lungs. Hence, in summer fruits and vegetables must be eaten, that the waste substance they contain may assist in preserving the daily, regular, healthy activity of these parts.*

493. Not only should these organs be daily active in removing from the blood substance which, if it remained, would produce headaches, sallow complexion, derangement of the digestive organs, but it is a golden rule, that

494. *There should be some regular hour when the colon*

* It is worthy of note, that nature has furnished to man plenty of fruits and vegetables in warm weather, which she has denied him in cold weather.

should be called on to remove from the system what had been removed from the blood.

The hour may be any regular one of the greatest convenience, except in case of people subject to nervous affections, headaches, disturbed sleep, nightmare, fits, &c., when the hour should be that preceding or at the time of retiring.

SECTION 2.—*The Liver.*

495. Some suppose the bile formed in the liver is of use in the digestive process only ; but that by the bile the system is relieved of substance harmful if it remain, and that the quantity of bile does not depend upon the digestive process entirely, seems to admit of very good arguments.

496. The liver is most active in warm weather.

At this time the lungs are most inactive ; the second stomach, and colon also, in health not active ; the kidneys inactive, and the skin active. Some argue that, though in summer there is less food required, the kind to be used requires more bile to digest it. But one or two other facts seem to point to another explanation.

497. The bile contains much carbon.

This, in summer, is produced in the system by its wear and waste, but must not be removed from the system by the lungs, or heat will be produced. It is not required, but would be injurious. In hot weather, therefore, the blood passing through the lungs is freed from its carbon only in a very slight degree ; for the lungs, full of warm air, contain comparatively but little oxygen, and as the air expands but little, if any, but a slight effect is produced ; but the liver being very active, removes carbon in plenty. If this be correct reasoning, it accounts for the fact, that

498. The lungs and liver sympathize with each other, as the expression is.

That is, if one fails to fulfil its duty, the other will be forced to do it ; on which account the circulation must be increased, and this continued for a short time produces exhaustion of the part, inflammation, or some other complaint.

The activity of the liver is also exhibited by the fact, that

499. In summer, exposure of the skin to cold tends to produce disease of the liver.

For the cold acting on the skin contracts it, and the blood, of which its vessels are full, is thrown inward, and is apt to congest the organs of greatest activity. In winter, this affects the lungs of almost all persons, but in summer, as necessity occasions greater activity of the liver, it will be overcharged with the blood which in winter burdens the lungs, and a summer complaint instead of a cold results.

500. In summer, those who eat large quantities of food adapted to produce heat and fatten the system, are very subject to affections of the liver, and their consequences—summer complaints.

For if the food be digested, it must be removed from the system, or deposited in the form of fat. It must not be removed by its natural outlet, the lungs, but by the liver; and in further proof of this it will be found, that those who grow fat are not troubled with affections of the liver so often as lean people who eat the same kind of food.

501. A fact in regard to animals tends to prove the same thing. Geese and other animals, made very fat by a process of stuffing, have their livers enlarged to a monstrous size. Swine are almost invariably affected with disease of the liver; while animals of a lean character naturally, and depending much on the lungs for heat, are almost as usually affected with disease of the lungs. Sheep, for instance, after shearing, are greatly troubled with inflammation of the lungs.*

502. Persons affected with disease of the lungs, which prevents their action upon the air in a sufficient degree, have disease of the liver.

As in consumptive cases, &c. This may be the reason of the condition like summer complaint, which is apt to be exhibited in the later periods of consumption.

503. Thus causes of disease of the liver, and the consequent summer complaints, and many derangements of the digestive organs, may be considered as generally resulting from

* Of more than two hundred lights of sheep used by the writer in experimenting, only those of two sheep have been found healthy; while of an equal number of hogs' lights, very few were affected.

not eating sufficient waste food, eating too much fat or heat-producing food, exposure to cold, and incapacity of the lungs to perform their duty.

The above causes are only the more common causes of disease of the liver, &c. As the formation of bile is dependent on the reception of blood of two kinds, the arterial blood and the blood from the portal vein (Lith. Pl. 4, Fig. 4), and on nervous influence from the nervous system of organic life direct, and by the exertion of the mind indirectly;

504. Causes of disease of the liver and its consequences may, therefore, also be looked for in the quality and quantity of the blood, in the general health of the system, and particularly of the digestive organs; as by the portal veins there is a very intimate relationship established between all the organs of this group.

The liver is not, therefore, the originator of all the diseases that are attributed to it; hence, to prevent and to remove its diseases or their consequences, attention must be given to the causes of disease existing in the given case.

Section 3.—*The Lungs.*

505. These organs remove carbon and water from the blood, and also various substances in very small quantities, depending on the character of the blood.

If it contain alcohol, for instance, the lungs will be assiduous in removing it, as a dangerous enemy of the system; hence the breath will be odorous, and not merely because a portion of the beverage remains in the mouth from which it is exhaled.

The chief object of removing the carbon has been shown to be to produce heat, but the system is so perfectly organized, that

506. If the carbon be not eliminated from the blood, it tends to injure the action of every part, especially the nervous system.

For if certain kinds of air be breathed, not in any way affecting the lungs, except by preventing the reception of oxygen—the agent causing

the purification of the blood in the lungs—stupor will soon be produced. If the oxygen be in small quantities only, an inactivity of the system, want of vivacity or animation in the eye and in the movements will be caused; a want of life will be exhibited in the complexion; the depression of the nervous system will tend to cause dyspepsia, inactivity of the liver, and derangement of all the organs of the second process of digestion; the action of the heart will be enfeebled. All these results, with the tendencies mentioned in Sec. 2, as being produced by the non-removal of carbon from the system, together with the effects of non-production of heat, (from want of oxygen and non-removal of carbon by which heat is produced,) are most unfavorable to health, beauty, and longevity. It therefore follows from this consideration of the duties of the lungs, that

507. Health, mental and physical, beauty, elasticity of body or mind, strength of intellect, or development of the powers of the system, and longevity, are unattainable without the inhalation of pure air in proper quantities.

Hence, all who desire the above inestimable blessings must leave the system uncompressed by clothing, must exercise the respiratory organs in all proper ways, and ventilate their apartments night and day.

Section 4.—*The Kidneys.*

508. These organs are two in number; one upon each side of the back-bone in the region of the loins, the one upon the left side being a little above the level of the other.

509. They are permanent in their position, and usually buried in a large quantity of fat.

At the top of the kidneys is a small part called the renal capsule; its use is not known.

510. The color, size, internal and external appearance of the kidney, is much like that of the swine.

511. Its use is twofold. First, to remove certain solid substances;

Which, however, must be removed by being dissolved in a large proportion of water.

512. Secondly, it is the duty of the kidneys to remove fluid from the blood, when the bloodvessels are too full.

For instance, if the skin be exposed to cold, and is contracted, the blood is thrown inward, congesting or overcharging some of the internal organs—suppose the lungs; the chest will feel "stuffed," viz., full, as in reality it is, and sufficient air cannot be inhaled. The nervous system instantly exerts itself upon the kidneys, enlarging their bloodvessels, the watery contents of which are at once diminished, and the chest feels relief: it therefore follows, that

513. The kidneys must depend for their action upon the reception of blood and nervous influence.

More blood passes to the kidneys than to any other parts of the body of the same size. Its arteries are very large. No gland or part in the body exhibits the regular and powerful action of the nervous influence of organic life, more than the kidneys—while, fortunately, no part of the body is less influenced by any state of the mind. For the action of the emotions and varying states of the mind produce such an effect upon the system generally, and some parts in particular, that the uninfluenced action of the kidney is required to prevent too great disturbance of the circulation. Another striking proof of the perfection reigning in the whole system—and with thousands of others, similar, induce the most implicit confidence in the supervising power of the Ruler of the universe and the Creator of man.

SECTION 5.—*The Skin.*

514. The duties of this organ are performed so quietly that its importance is usually overlooked, or very much undervalued. It has been demonstrated by many, and can be by every person for himself. Sanctorious, an Italian, weighed himself and all he ate and drank, every day for thirty years; the result of his experiments prove that in his case, about five-eighths of all that was taken into the system, was at last removed by the action of the skin and lungs.

515. Seguin and Lavoisier made more accurate experiments still; for by inclosing themselves and other persons in glazed bags with an opening glued about the mouth, they were enabled to distinguish between the excretions of the lungs and skin; and they came to the conclusion, that

upon an average two pounds pass from the body in 24 hours, by the action of the skin in health. One pound, under the most unfavorable circumstances, would be lost by the action of the skin, and five pounds in a single hour, under the most favorable circumstances.

516. Some persons engaged in glass-blowing were weighed by the writer some years since, in mid winter. One man weighed 170 pounds with his clothes removed. They were replaced, and his labor continued for an hour and three quarters, when he, with others, was again weighed; his weight was then 166 pounds, he had lost 4 pounds' weight by the action of the skin and lungs; the person who lost the least, lost two and a half pounds. The results were so surprising to the parties they would hardly believe them, and the loss is so gradual and imperceptible, that few persons have a *practical* belief in respect to the action of the skin in *their own* case.

517. The substance passing from the skin may be considered as of three kinds: 1st. The oil previously spoken of, exuding for the purpose of benefiting the skin itself. 2d. The perspiration, properly so called; it is the water portion of the blood, perspired that by evaporating from the surface it may cool the body. 2d. Excreted substance of varying character, as the case may be, but very injurious if retained in the system.

518. The skin therefore in health, in addition to the duties mentioned in the section upon the nervous system, performs two duties, each of momentous importance. It cools the body, more or less rapidly, and thus regulates the temperature; in the next place, it removes waste or useless substance from the body.

519. To accomplish these duties, the skin must evidently be liberally supplied with blood.

520. This is accomplished—

a. By exercise.

For exercise drives the blood through every part of the body, and the muscles, by pressing upon the bloodvessels leading to and from the skin, will hurry the circulation through the skin.

b. By rubbing.

For every one, from experience, knows how much this increases the circulation through the skin. When a person is sick, and cannot take exercise, the rubbing becomes doubly necessary.

c. By protective clothing and shelter.

Cold necessarily acts on the bloodvessels with a tendency to contract them, and there is such liability of the skin to exposure to the cold, its surface is so extensive, that the greatest care must be taken.

d. By the action of the nervous system of organic life.

This is the power which resists more or less effectually the action of the cold. Its influence upon the skin is very powerful in healthy persons. When it is wanting, the bloodvessels of the skin become bloodless, and heat alone will not give them life and energy. The poor sufferer with the fever and ague, hopes that the heat of the fire will warm his bloodless skin and give him relief from his chillness, but he is disappointed ; the want of energy manifested by the nervous system will prevent him from receiving a particle of benefit from the warmth ; as the state of the nervous system depends on the state of the general health.

e. By whatever tends to improve the general health.

Ill health of any organ, by acting first upon the nervous system, must nevertheless, have the effect to derange the circulation of blood in the skin. Thus the dyspeptic is apt to feel a coldness of the skin, and any or all causes of ill health or exhausted states of the system, will produce derangement of the "cutaneous" (skin) circulation, and all the consequences of it.

521. The substances passing from the skin, make their exit through exceedingly small holes (Fig. 123), which are likely to be closed by any thing adhering to the surface of the skin ; and as there is much substance passing from the skin, it may be very easily glazed over, to such a degree that its duties cannot be performed.

522. It is necessary to avoid all causes which tend to prevent substances separated from the blood, from passing out of and away from the skin ; for which purpose,

a. The skin must be often and thoroughly cleansed.

For the large amount of substance passing from the skin is very liable, indeed certain, by drying to form a gum or glazing upon the surface of the skin, which closes over the very small openings through which the oil, perspiration, &c., are removed, preventing their discharge and

causing them to remain in the system, except thrown out by some other organ.*

Fig. 123.

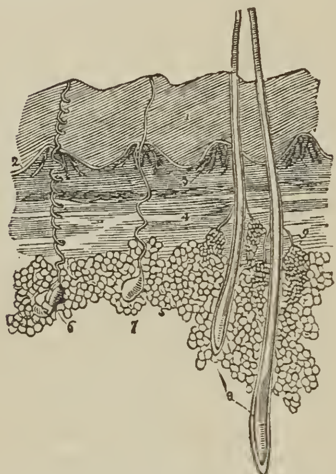


Fig. 123.—Section of the skin magnified. 1, The cuticle, the proportionate thickness of which varies. 2, Rete mucosum (mucous net-work) so called because it is of pasty consistence and viewed over the layers beneath, appears in the form of a net-work. It varies in color according to the constitution of a person, its frequent deposition from the blood, and the action of the air upon it. 3, Papillæ, in which the nerves commence. 4, Cutis-dermis or true skin, in which all the active duties of the skin are performed, and which in health depends on the reception of blood and nervous influence by the skin, and on its being kept clean. 5, Cells containing fat. 6, Perspiratory gland, with a spiral duct, such as seen in the hand or foot. 7, Another gland with straight duct. 8, Two hairs. 9, A pair of oil glands with tubes opening into the hair sheath

* The question is frequently asked, Which is the best means of cleaning the skin? The answer is, That way which is most agreeable to a person, if the system be perfectly healthy; if it be not, care must be taken not to expose the skin to any cause of chill, to which a person will be liable in proportion to the feebleness of the system, produced either by disease or exhaustion. When cleaning the skin, there are other effects directly produced, which render it advisable to take a view of the different ways at present adopted. Some merely rub the skin with a coarse towel, hair-rubber, or the like; this is very good, and sufficient in many cases, if done very thoroughly and as often as twice per day. If this be done for the sick, the body must not be entirely uncovered at once, as the nervous system will not be able to resist the cold, even if slight, when acting upon so much surface as the whole body presents. How much of

b. The clothing surrounding a person, either that which he wears or covers himself with during sleep, should be frequently cleansed.

the system may be exposed, will depend *upon the health of the person and the temperature of the room.* The *best* thing, not to say it is the cheapest or most convenient, with which to rub sick or well persons, is a pair of stocking-feet, more or less worn, according to the delicacy of the skin.

Some wash the skin with cold water; this is well if reaction be immediately produced, which can only be determined by experiment. It must not be tried by any one, however, who has any active inflammation of the internal organs, for when cold acts on the skin, it always drives the blood inward, if only for an instant, and there is therefore increased inflammation. This action, however, may be in some cases followed by "reaction," that is, such an enlargement of the bloodvessels of the skin, that the quantity of blood in the inflamed part is lessened. It is, therefore, a very delicate matter to apply cold to a feeble person so as not to be injurious, and there is such a latitude of effects produced, that though it appears so simple, there is probably no remedy or thing that requires more skill in its application than cold water. If it be applied, and reaction does not take place, brisk rubbing, and if the person can bear it, active exercise should be immediately used. The extent of surface which may be washed at once, and the degree of cold, must depend upon the health and warmth of the body, and upon the temperature of the apartment. *It is always to be kept in mind, that all applications of water produce a cooling of the system by evaporation,* which is all the greater on account of the warmth of the body.

Some dash, pour, or shower cold water upon the skin. These things tend to drive the blood inward and to produce reaction if the system be sufficiently vigorous. The effect is powerful, as the running of the water over a great extent of surface, removes a great deal of heat, and the nervous system will arouse all its energies to rescue the body from the evil to which it is exposed. When, therefore, the energies of the system are torpid, such applications are highly beneficial; but when the system is in reality feeble, the greatest harm would follow from such experiments, which must not, therefore, be tried even for once, by those who have active inflammation or tendency to it, in any of the internal organs.

Some go into the water, or apply it to themselves continuously. In this case the action of the water removes a great deal of heat, and proves beneficial when the system is not feeble, and manifests reaction immediately. It should not be continued till chill is felt, as the powers of the system can only produce a certain amount of heat with profit. Boys frequently enfeeble the system by going into the water too often. There is nothing exhibits more strikingly the necessity and healthful effect of heat upon the system. The body is not made stone cold by bathing, but a lower degree of temperature than is natural to it is produced and continued, and the powers of the system are more completely un-

If a person try the experiment of weighing his clothing before and after it is washed, he will find its weight is increased by wearing it. By trying a series of experiments, he will find his clothing is more soiled if

dermined than by any other cause. The same evil is more gradually but as certainly produced by young ladies who dress too thinly, by which they are continually in a bath of cold air, slow but sure in its tendencies to consumption, and every other complaint which is consequent upon a depressed state of the temperature of the body for any length of time. The degree of cold, and the length of time during which a person may take this kind of bath, depends upon the health.

Some prefer warm applications in place of cold. They are better for the purpose of cleansing the skin, but they do not excite the nervous system to action, and are much better adapted to feeble health than cold baths, as they add heat rather than remove it. It is however to be observed, that they evaporate more readily than cold water, and a person will sometimes feel a decided chill when washing before a hot fire, the evaporation causing so much heat to be removed from the system. This is especially worthy of notice when a person is unwell.

Some persons, and among them the author, prefer the vapor bath, as it cleanses the skin more readily than any other simple thing, and is the quickest and most comfortably taken of all baths; while, if properly taken, a person cannot be in the least danger of taking cold. Like all warm baths, *they should not be applied to the head without there is some imperative necessity for it.* On the other hand, cold should be applied to the head—the principle being always judicious, "to keep the head cool, and extremities warm." *In the second place, they should be taken only till the perspiration begins to start.* This will be first perceived on the forehead, though it be not exposed to the vapor, with which the body may be very wet. If there be but little blood in the system, the enlargement of the vessels by the warmth applied to so great an extent of surface may cause the blood to be drawn from the feet; if they be cold, as in such or any case, they should be put in warm water. The modes of taking vapor baths are various. Any plan of producing the vapor is sufficient, but the more rapidly it is produced, the better. One of the most important things is, to have the covering surrounding a person thick, as this prevents the vapor from depositing on the covering, and causes it to deposit on the body. An extempore bath can be produced by placing a pail of water (if hot the better) under a chair in which a person sits, and covering him, except the head, with thick "comfortables," quilts, blankets, &c. (one thickness of blanket is not sufficient), and then dropping heated stones, burning coals, or any thing hot, into the water in the pail. As soon as the perspiration starts, the skin should be rubbed till dry, when a person may retire or go about his business. If he be well, he may, if he choose, wash the skin with cold water, take a shower or plunge bath, as do the Russians; for as the vapor has warmed him, he will not be injured if the cold water remove heat. There is no danger in using the bath at any time, except just after eating; it soothes the nervous system, circulates the blood more rapidly, and has a remarkable tendency to calm a person

he frequently cleanse the skin, and also if the clothing be frequently changed. The amount of substance passing from the system can be demonstrated to affect the clothing of the bed, not only by the sense of smell, but by weighing the clothing put upon the bed in fall, and again in spring. In sickness, therefore, a person should have his linen very frequently changed, and several times per day he should, if not too feeble, be changed from one bed to another, that the clothing of the one he has left may be opened and aired. NO PERSON CAN RECOVER FROM ILL HEALTH SPEEDILY, WITHOUT EVERY THING BE DONE NECESSARY TO FACILITATE THE ACTION OF THE SKIN.

c. The air in which a person lives should be kept in as proper a state as possible, to facilitate the passage of substance from the skin.

If the air be warm and dry, evaporation from the skin takes place rapidly, while if it be moist and hot, the system is very much oppressed, as every one has experienced. This shows the importance of the cutaneous action. If the weather be damp and cold it is exceedingly unfavorable, as the excretions cannot pass from the system through the skin, while the damp air by its nature or condition removes much heat. Hence cellars and like places are the most unwholesome of abodes; for if warm they are usually damp and unwholesome, if they be cold and damp as usual, they must be productive of very much disease.

for repose. The rubbing that should follow it, and the application of cold to any part requiring its influence, is most excellent when a person feels stiff and weary, rheumatic, &c. *A person must be careful not to use it for too long a time, which he is liable to do, it being so soothing.*

Some think an air bath, hot or cold, exceedingly serviceable. The direction of Franklin was doubtless discreet, that if a person feels restless and sleepless, he should rise, throw open the clothing, and walk the chamber for a few moments.

Some have great confidence in what are called medicated baths; but there would seem to be very little effect produced by these, except what is caused by the application of heat or moisture, or both combined.

Some use soap in connection with the baths. If this be in small quantities, so as to remove only the oily substance from the surface of the skin, it is not injurious, and may be recommended; but used plentifully, it tends to draw out the oil from the skin.

Some use alcoholics, acids, &c., upon the face or the entire skin. They may be used, but very unfrequently; frequently used, they render the skin harsh, dry, and liable to chap, crack, &c.

523. If the skin from any cause cannot perform its duties, they must be fulfilled by some other organ, or the system will quickly suffer.

If the perspiration be not removed, the heat of the system will accumulate and a feverish state soon exist, as there is no other part of the body which can fulfil this duty of the skin. In such case the heat of the system can be lowered only by drinking water and sponging the surface with cold water, which by evaporation and conduction will remove the excessive heat of the body; and as it is always harmful to have the temperature of any part above the natural degree, it should be kept down by the above means, which will produce a chill if used to excess, and thus indicate when harm is commencing.

If the excretion be not removed, it is usual for the lining of the nose to first undertake all it can do; hence why a person has a "cold in the head." Next the continuation of the same lining in the air passages will undertake the duty unperformed by the skin, and there is a cold in the chest. Sometimes the lining of the second stomach undertakes the task, and a summer complaint is the result.

524. When therefore the skin from inaction causes increased action of the air passages, or digestive canal, its action must be increased.

If this be done in the outset, the complaint will be easily removed, but if it be allowed to continue a short time the "cold will have a run."

525. Such being the cause of colds, it is easy to prevent them by clothing the skin properly, by rubbing the skin, and bathing the skin in such a manner as most perfectly to preserve the action of the skin.

526. Also, if there be chronic affections of the air-passages and digestive canal, it will be highly desirable to produce and continue a very active condition in the skin.

527. All those things which are for the health of the skin improve also its beauty.

Its complexion depends upon the coloring matter deposited from the blood and acted upon by the air; there must, therefore, be an active circulation of blood, and the skin must be kept clean. Exercise, warm

clothing, especially of the hands and feet, brisk rubbing, &c., improve beauty.

528. The same things also improve the appearance of the hair, which is an appendage of the skin (Fig. 123).

It grows from the blood, is perfected by oil, which is also formed from the blood. It is therefore advisable to preserve an active circulation of blood about the roots of the hair, and when it is falling out, to attempt to reproduce it by brushing the places where it is desirable to have it appear.*

* A most excellent treatise on the skin, has been written by Erasmus Wilson, for popular reading. In it directions, with the reasons, are given for treating the healthy skin, and also the most common affections of this organ. It was deemed so valuable that I procured its republication in a cheap form, and added to it some notes, hoping to increase its value. It is illustrated by sixty-two beautifully engraved figures on six steel plates, which with its style and instructive matter, render it intensely interesting. It may be had of the publishers of this work, in paper covers, 37½ cents, single; $3 per dozen.

CHAPTER VI.

THE ORGANIC NERVOUS SYSTEM.

529. This is also called the sympathetic nervous system. The source of the influence exerted by this system is not known; there are probably several sources.

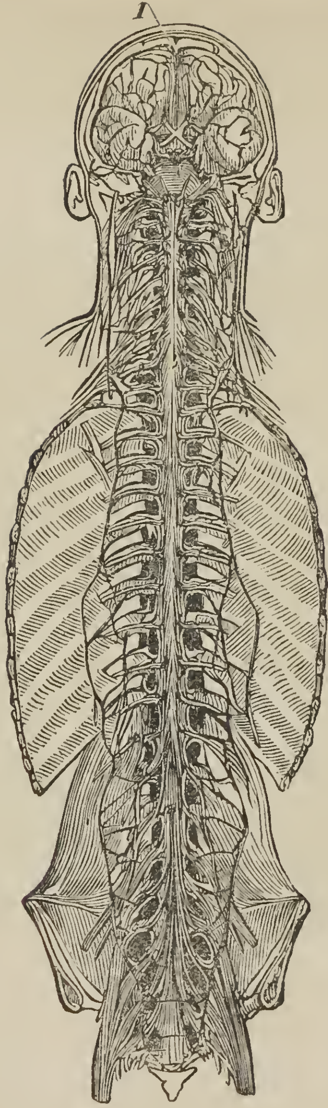
530. Upon each side of the back-bone and a little distance from it on the inside, there is found a chain of nervous substance (Fig. 124). It consists of small lumps of grayish colored nervous substance called ganglia, connected by minute white cords, containing also gray substance. From the ganglia, connections extend to the neighboring nerves of the spinal system.

531. Nerves from this chain pass off on the large blood-vessels, as some believe, to the extremities of the arteries, but this is uncertain.

532. It has been suggested that this is a nervous system for the purpose of harmonizing the action of all parts of the body, but of this there is no proof.

533. All that can at present be said, is, that there is an arrangement in the system by which the action of every part produces an influence on every other part. By this arrangement, the action of every part in health is increased or diminished as the wants of every part and the whole system may require; of which there have been given so many illustrations in the preceding pages, it is hoped that the reader has arrived

Fig. 124.



at the conclusion that the physical suffering which he endures is not the fault of the organization of the system, but of himself; in not learning and observing those wise laws established by the Creator for the happiness of those who observe them.

Conclusion.

When all the principles developed by studying the wants of every organ are reviewed, the laws to be observed for the preservation of health, &c., are found to be very few, and easily regarded; to wit, all the organs of the body must be properly exercised, that is, neither too much nor too little; regularly and lightly at first. Food is to be chosen in accordance with the temperature of the weather, exposure, and exercise of the system; prepared without much spice or seasoning; taken neither very hot nor cold; thoroughly chewed; and in such quantity as to merely satisfy a healthy appetite. Drink, which should be pure water, is to be taken when a person is thirsty. Pure air must be breathed. The skin kept clean, warm, and often rubbed. Regular habits in every respect should be formed, and a cheerful, amiable, and active state of mind must be cultivated and preserved. If sickness do come, the mental and physical system must be allowed rest from all its duties, and all the laws of health must be most strictly observed; as the first rule should be, not to oppose nature. If then, she need assistance, it is evident, that those best qualified by honesty of feeling, natural talent, acquired knowledge, and experience, are the only persons in whom confidence can be placed.